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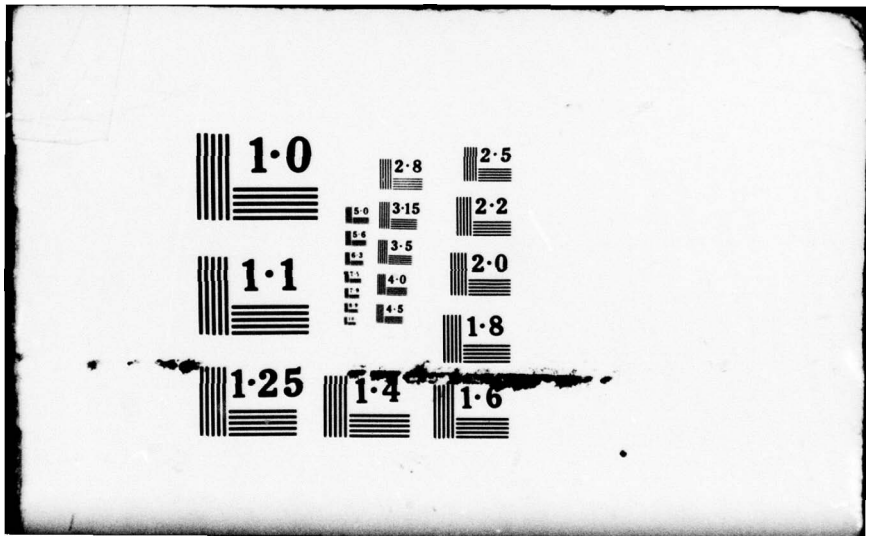
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(10) Timothy J. /Bailey, Michael R. /Anderson
Ross W. /Snare

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US Army Combined Army Combat Developments Activity
Fort Leavenworth, Kansas 66027

CARMONETTE BATTALION LEVEL GAMING CONDUCTED FOR DIVISION RESTRUCTURING EVALUATION

by
Timothy J. Bailey
Michael R. Anderson
and
LTC Ross W. Snare

ACN 39307

Approved by:

RICHARD C. RINKEL
Chief, Analysis Division

LELAND C. PLEGER
Deputy Director

ROBERT T. REED
COL, AR
Director

FOREWORD

The authors of this report wish to recognize the other members of the Division Restructuring Evaluation (DRE) Battalion Gaming study team and acknowledge their determined efforts without which the successful completion of this study would have been impossible. Thanks are given to Mr. Ronald G. Magee, Mr. Gerald A. Martin, and LTC James M. Wiles for their efforts in developing the scenarios and conducting the war gaming; to Mr. Robert A. Davison, Mr. Rudolph J. Pabon, Ms. Sandra C. Elliott and Ms. Martha L. Moody for their efforts in the preparation of the data base; to Mr. Ross A. Wells, Mr. Harry P. Jones, and Mr. James H. Kennington who provided modeling support; and to Mr. William G. Martin whose assistance in the development of the CARMONETTE graphics postprocessor was invaluable.

The authors also wish to acknowledge the Threats Division, Concepts, Doctrine and Literature Directorate, Combined Arms Combat Developments Activity (CACDA) who provided the threat force arrays; and the Department of Tactics (DTAC) of the US Army Command and General Staff College (CGSC) who reviewed and approved the tactics used in this study.

The authors wish to express their gratitude to Mrs. Elizabeth W. Etheridge who served as technical editor for this report, and Ms. Laura B. Weishaar and the Word Processing Center for their help in the typing of this report.

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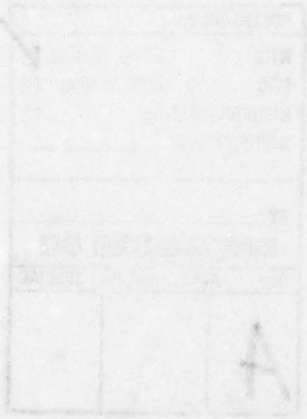
ABSTRACT

This study was conducted as part of the analytical support provided by the Combat Operations Analysis (COA) Directorate of the US Army Combined Arms Combat Developments Activity (CACDA) to the Division Restructuring Evaluation Office (DREO) during the Battalion Phase of the Division Restructuring Evaluation (DRE). This study examined the combat effectiveness of four alternative battalion task forces in various combat scenarios. CARMONETTE was used to model the combat in this study. This report contains a description of the four alternative organizations, a discussion of the analysis methodology used, the results of the CARMONETTE gaming, the statistical and inferential analyses of the results, and the findings of the analyses. Additionally, a detailed description of the three combat scenarios used for this study is provided in this report.



CONTENTS

CONTENTS (Concluded)

LIST OF TABLES

LIST OF TABLES (Cont)

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LIST OF TABLES (Concluded)

LIST OF FIGURES

LIST OF FIGURES (Cont)

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EXECUTIVE SUMMARY

1. PURPOSE. The purpose of this study was to determine differences in the combat effectiveness of battalion organizations derived from a current armor division and a restructured heavy division by extending the results of the Division Restructuring Evaluation (DRE) battalion field test into the 1985 time frame through simulation against a postulated European threat.

2. BACKGROUND.

a. The Division Restructuring Evaluation (DRE) is the evaluation phase (Phase II) of the Division Restructuring Study (DRS). The purposes of DRE are twofold:

(1) To compare the effectiveness of the restructured heavy division to that of the current armored division and to evaluate the adequacy of the restructured heavy division with respect to the interface with related echelons above division and improvements in efficiency of organizational unit training.

(2) To recommend improvements to current divisional organizations configured with the current weapon systems and to develop preferred alternative organizations for testing as the future weapon systems become available.

b. The proponent for DRE is the Force Structure and Design Directorate (FSD); a part of the US Army Combined Arms Combat Developments Activity (CACDA) located at Fort Leavenworth, Kansas. As proponent DREO has the responsibility to design and implement the DRE Independent Evaluation Plan (IEP). The IEP contains a description of the restructured heavy division in terms of its major combat systems, a discussion of the evaluation issues, their criteria for evaluation, and the organization and responsibilities for accomplishing the evaluation. The IEP is updated, as necessary, to reflect the findings of completed testing and analysis and/or guidance provided by CSA in-process reviews and other major decision reviews. The IEP is formally approved by the Commander, TRADOC and the Commander, OTEA after each major update.

3. OBJECTIVES. The objectives of this study are twofold:

a. To measure and compare the combat effectiveness of a battalion task force derived from a current (H-series) armor division and one derived from the restructured (T-series) heavy division operating against a 1985 threat in a Central Europe environment.

b. To ascertain the contribution of the major direct fire weapon systems to any measured differences in combat effectiveness.

4. SCOPE.

a. This analysis examined differences in combat effectiveness between battalion organizations derived from the proposed restructured (T-series) heavy division and the current (H-series) armor division.

b. H-series tank organizations were compared with T-series tank organizations, and H-series mech organizations were compared with T-series mech organizations. No direct comparisons were made between tank and mech organizations.

c. The analysis was conducted in the mid-1980 time frame by updating the alternative organizations with weapon systems whose IOC dates were within the specified time frame. The threat force, provided by Threats Division, Concepts, Doctrine and Literature Directorate, CACDA, was also updated with the capabilities postulated by 1985.

d. The standard scenario for combat developments, Europe I, Sequence 2A was the framework within which the analysis was conducted.

5. LIMITATIONS/CONSTRAINTS.

a. The interactions among the organizations being evaluated and other US and friendly nation forces were not evaluated.

b. The effects of air defense, attack helicopters, and TACAIR were not considered in this analysis.

c. Since the current (H-series) battalion is larger than a restructured (T-series) battalion, the comparisons were made using a current task force organization in which the number of major weapon systems in the organizations being compared were about equal while maintaining unit integrity.

d. Force costing of the organizations being compared was not addressed in this analysis.

e. This study was constrained to use the individual weapon system mobility rates measured during the DRE Battalion Field Test held at TCATA. These mobility rates were derived by CACDA from the movement records of the instrumented weapons.

f. IFV/CFV mobility rates have been determined to be compatible with the XM1; thus, the tactical mobility rates of the IFV/CFVs were considered to be the same as the XM1 tactical mobility rates.

6. METHODOLOGY.

a. General. CARMONETTE was used as the combat simulator for this study. The CARMONETTE run design, developed to address the objectives of this study, contained three run sets. The run sets were developed to stress different aspects of the alternative armor and mech organizations performing various missions in two European terrain areas.

(1) Run set 1. This run set evaluated the alternative tank and mech organizations in a position defense conducted against the Red force attempting to cross the Fulda river in terrain area 1, which is between the cities of Niederaula and Niederjossa. Since there is little movement by the Blue force, this scenario stresses the ability of the Blue force to service Red targets effectively and quickly.

(2) Run set 2. The second run set was designed to measure the performance and evaluate the effectiveness of the alternative organizations while conducting offensive operations. These scenarios, conducted in terrain area 2 (vicinity of Arzell/Eiterfeld), tested each Blue organization's ability to maneuver and bring its firepower to bear on the Red force.

(3) Run set 3. The last run set was developed to evaluate the Blue force task organizations in a covering force operation. These scenarios were also developed in the rolling terrain of area 2 and also stressed the ability of the Blue organizations to maneuver their firepower against the Red force.

b. Analysis Techniques. The analysis performed on the results of the CARMONETTE gaming was conducted in two parts. The first part consisted of applying various statistical techniques to the results of the 25 replications made for each organization in the run sets. The statistical techniques employed included multivariate hypothesis testing using the Hotelling's T^2-statistic and the construction of simultaneous confidence intervals. These statistical procedures were used to identify significant differences in the gaming results and to determine the sources of any observed variations. The second part of the analysis was conducted to ascertain if any of the observed significant differences would be significant in a practical sense to a commander in the field. This part of the analysis utilized a number of inferential analyses based on the results of the statistical analyses.

7. RESULTS.

a. Comparison of H-Series and T-Series Tank Organizations in the Position Defense Scenarios. The H-series tank organization displayed more combat effectiveness in both a statistical sense and a practical

sense in the position defense scenario. The key to the H-series tank organization's greater success was the ability of the H-series XM1s to better service the Red targets. The ability to task organize for combat allowed the H-series tank organization to deploy its XM1s in positions where they were closer to the main attack. Thus, they were able to attain a greater loss exchange ratio and kill a larger percentage of the Red force than the T-series XM1s.

b. Comparison of H-Series and T-Series Mech Organizations in the Position Defense Scenarios. The T-series mech organization was found to be significantly more combat effective than the H-series mech organization. There is a threshold of firepower that must be brought to bear to defeat an enemy force. The H-series mech organization, deployed and configured by doctrine, was able to block the main attack using slightly over half of its weapons with minimal support from the remaining weapons. This amount of firepower was apparently below the winning threshold. The T-series mech organization was able to bring about two-thirds of its weapons to bear on the Red force, including all its high rate of fire weapons (XM1s). This level evidently was sufficiently above the firepower threshold to defeat the enemy.

c. Comparisons of H-Series and T-Series Tank Organizations in the Deliberate Attack Scenarios. Examination of the gaming results uncovered a problem within CARMONETTE with the artillery/mortar fire allocation procedures that influenced the outcomes in favor of the T-series tank organization. The degree of influence is uncertain. Thus, although the statistical analysis found the difference in combat effectiveness to be numerically significant, plots of the surviving maneuver force ratio differential (SMFRD) showed the T-series tank organization as only marginally more combat effective. Thus, it is questionable in a practical sense whether the T-series organization was significantly more combat effective.

d. Comparisons of the H-Series and T-Series Mech Organizations in the Deliberate Attack Scenarios. The main contributor to the Red losses in the mech deliberate attack scenarios was found to be the TOW vehicles. This was primarily due to the superiority in numbers of TOW vehicles as compared to the number of XM1s in each mech organization. The T-series mech organization statistically displayed more overall combat effectiveness than did the H-series mech organization. Nonetheless, examination of the SMFRD plots indicated little practical difference between the outcomes of the battles of the respective organizations.

e. Comparisons of the H-Series and T-Series Tank Organizations in the Covering Force Area Scenarios. In the covering force scenario the T-series tank organization displayed a statistically significant difference and a tactical advantage in combat effectiveness over the

H-series tank organization. Examination of the individual weapon system performance parameters found that, on a per weapon basis, the H-series XM1s and TOW vehicles performed slightly better than the T-series weapons. However, the H-series weapon systems incurred heavier losses, which resulted in the T-series XM1s and TOW vehicles being more effective. The differences in survivability appear to result from differences in the initial emplacements of the weapon systems and tactics used in the respective battles.

8. FINDINGS.

a. Although the observed differences in the performances of the individual weapon systems when grouped as either a T-series or an H-series organization were not consistently the same over all the scenarios, a few general trends were observed and are presented below.

(1) The company team concept should be incorporated into the T-series doctrine. In the defense, this concept provided the gamer the flexibility to employ the most effective mix of rapid fire and long range weapon systems as dictated by the situation. In the offense, a variety of man-made and natural obstacles may need to be reduced or destroyed, thus requiring infantry to dismount. Occasions also frequently arise that require the rapid fire characteristics of tanks to reduce enemy fires. Thus, the company team concept is best suited to cope with the varieties of situations encountered on the battlefield.

(2) The scenarios in which the Blue force had to effectively maneuver its weapon systems found that the T-series organizations were consistently able to maneuver more of their weapon systems into the battles. Thus, the T-series consistently fought the battles with more weapon systems than the H-series organizations. This difference in the performance of the weapon systems is attributed to the fact that the T-series weapon systems were organized into three companies whereas the H-series weapons were organized into only two companies. This difference in configuration provided the T-series organization with an additional axis of advance in the offensive scenarios and better mutual support during the fall back operations of the covering force actions.

(3) The configuration of three companies also gave an advantage to the T-series organizations in the position defense scenarios. The three companies could be placed where they could provide mutual covering support. The two companies under the H-series concept of organization were emplaced too far apart to provide effective support fires.

b. As presented in table i, the T-series organizations were found to be statistically more combat effective than the H-series organizations in four of the five comparisons. In two of these comparisons, those for the

offensive scenarios, the T-series organizations were shown to be statistically more combat effective; but for all practical purposes, the combat effectiveness of the alternative organizations was the same. In the remaining comparisons, which found both a statistical and a practical difference in combat effectiveness, the T-series organizations were found to be more effective in two of the comparisons and the H-series organization was found to be more effective in one comparison. Thus, although there were advantages associated with both organizational concepts, neither seemed to display a distinct advantage over the other.

Table i. Summary of CARMONETTE gaming analysis.

Scenario Comparison	Statistical Superiority	Practical Advantage
Position Defense		
H-tank vs T-tank	H-tank	H-tank
H-mech vs T-mech	T-mech	T-mech
Deliberate Attack		
H-tank vs T-tank	T-tank	None
H-mech vs T-mech	T-mech	None
Covering Force		
H-tank vs T-tank	T-tank	T-tank

1. PURPOSE. The purpose of this study was to determine differences in the combat effectiveness of battalion organizations derived from a current armor division and a restructured heavy division by extending the results of the Division Restructuring Evaluation (DRE) battalion field test into the 1985 time frame through simulation against a postulated European threat.

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(1) To compare the effectiveness of the restructured heavy division to that of the current armored division and to evaluate the adequacy of the restructured heavy division with respect to the interface with related echelons above division and improvements in efficiency of organizational unit training.

(2) To recommend improvements to current divisional organizations configured with the current weapon systems and to develop preferred alternative organizations for testing as the future weapon systems become available.

b. DRE is being conducted in four separate but overlapping phases:

(1) Developmental phase (February 1977-September 1978). This phase consists of several activities including evaluation and revision of restructured division operations manuals (RDOMs), unit ARTEPs, and tables of organization and equipment (TOE). The developmental phase also includes the restructuring and training of selected units for field testing.

(2) Battalion phase (May 1977-July 1978). This phase consists of the execution and analysis of several field tests and exercises, in particular the DRE battalion field test conducted at the US Army TRADOC Combined Arms Test Activity (TCATA) in October-December 1977.

(3) Brigade phase (January 1978-October 1979). This phase will consist of the execution of the DRE brigade field test, analysis of the test results, and preparation of the test reports.

(4) Analysis phase (April 1977-October 1979). The analysis phase encompasses the two testing phases and is being conducted to evaluate through the aid of simulations, models, and war games selected aspects of the alternative organizations in a 1985 time frame against a realistic European threat.

c. The proponent for DRE is the Force Structure and Design Directorate (FSD); a part of the US Army Combined Arms Combat Developments Activity (CACDA) located at Fort Leavenworth, Kansas. As proponent DREO has the responsibility to design and implement the DRE Independent Evaluation Plan (IEP). The IEP contains a description of the restructured heavy division in terms of its major combat systems, a discussion of the evaluation issues, their criteria for evaluation, and the organization and responsibilities for accomplishing the evaluation. The IEP is updated, as necessary, to reflect the findings of completed testing and analysis and/or guidance provided by CSA in-process reviews and other major decision reviews. The IEP is formally approved by the Commander, TRADOC and the Commander, OTEA after each major update.

d. As a part of the evaluation process, DCDR CACDA has tasked the Combat Operations Analysis (COA) Directorate of CACDA to provide analytical support for DRE. This report and its associated gaming is a part of the support provided by COA for the battalion phase of DRE.

e. The combat simulator used in this study was CARMONETTE. A description of the version of CARMONETTE used in this study is presented in paragraph 6.

3. OBJECTIVES. The objectives of this study are twofold:

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f. IFV/CFV mobility rates have been determined to be compatible with the XM1; thus, the tactical mobility rates of the IFV/CFVs were considered to be the same as the XM1 tactical mobility rates.

6. CARMONETTE.

a. General. CARMONETTE was last documented in 1974 by General Research Corporation (GRC) for the US Army Concepts Analysis Agency (CAA) (reference 1). Since that time CARMONETTE has undergone numerous revisions principally by CAA and the US Army TRADOC Systems Analysis Agency (TRASANA). The version of the model used in this study was obtained from CAA in May 1977. It is the version of the model used by CAA in the Advanced Attack Helicopter (AAH) study and is generally referred to as the "70-unit" version.

b. Model Description.

(1) General. CARMONETTE is a stochastic, event sequenced combat simulator, which models the combat of two opposing forces. The model simulates brief battles of up to 60 minutes of intense combat. Continuation of battles beyond 1 hour of combat is considered questionable in CARMONETTE. This is because CARMONETTE is loaded with a

given set of order data, which is executed sequentially through the battle. As the battle progresses, the situation changes until the original data set is no longer meaningful. The basic activities of combat that are modeled in CARMONETTE are movement, target acquisition, direct fire engagements, intelligence, fire support, air defense, and air operations.

(2) Units. CARMONETTE is gamed with combat units, which can be structured to represent any level of aggregate weapons from an individual man or weapon system up to a platoon of weapons. A maximum of 70 units is available to each force. In this study an attempt was made to structure units as individual major direct fire weapon systems and, in the case of dismounted personnel, rifle squads. This was accomplished, for the most part, with the Red defender force and for all Blue organizations. However, since the Red aggressor force was a motorized rifle regiment, its units were typically aggregated at platoon level in order to fit all the weapon systems of the regiment into the available 70 combat units.

(3) Orders. The units are made to move and fire in CARMONETTE through unit orders. Each unit has a string of orders that it executes sequentially during the simulated battle. The CARMONETTE order vocabulary used in this study included the following:

(a) NSTP - orders a unit to move without stopping; used for units that fire while moving.

(b) MOVE - causes a unit to change positions; used for units that cannot fire while moving.

(c) STAY - orders a unit to fire or wait.

(d) DISM - causes a passenger unit to dismount from its carrier unit.

(e) REMO - causes a passenger unit to remount into its carrier unit.

(f) SKIP - causes a unit to skip a number of orders determined by a qualifier in its order string.

(4) Terrain. The terrain in CARMONETTE is divided into a grid of 60 x 63 squares. The size of the grid can vary depending on the data available and the scenario being gamed. The size of the grid squares in this study was 100 meters square. It was considered necessary to use 100-meter grids to obtain a reasonable resolution of the terrain in the model. Therefore, the total size of the terrain "box" was 6.0 x 6.3 kilometers.

c. Model Limitations.

(1) The maximum of 70 units per side is a limitation. Aggregation of weapon systems in units has been acknowledged by the CARMONETTE user community to be questionable because of the degradation it causes to some of the combat processes modeled.

(2) This version of the model had no capability to play minefields or CLGP.

(3) CARMONETTE has a rather simplistic representation of the artillery/mortar processes for target selection and fire support resource allocations.

(4) This version of the model was not considered to contain a realistic representation of smoke, so no smoke or any other kind of limited visibility was played.

(5) Although the 100-meter square grid provided a reasonable terrain resolution, it limited the expanse of terrain upon which the gamers had to maneuver their forces. As a result, some modifications had to be made to weapon deployments and tactics to accommodate this lack of maneuver room.

(6) In CARMONETTE units are always located at the center of a 100-meter square grid. Thus, the gamers could not optimize a weapon's battle position within a grid.

(7) The orders available in the CARMONETTE vocabulary were not sufficient to conduct organizational unit maneuvers. Thus, it was necessary to correlate with respect to time the orders of the individual combat units common to an organizational unit to attain any coordination of movement among the weapon systems.

(8) Aggregate CARMONETTE units must be homogeneous; that is, they can contain several weapon systems, but all the weapon systems must be the same. This constraint required some modifications to the organizations gamed in the units that by necessity were aggregated.

d. Model Modifications for DRE.

(1) CARMONETTE had to be converted from the UNIVAC version used by CAA and TRASANA to a version that would execute on a CDC 6400/6500 computer. This task was accomplished by CACDA/COA.

(2) The terrain representation in CARMONETTE was changed to one similar to that used in the DYNTACS-X model. The primary benefits in making this change were as follows:

(a) An improved terrain representation. The old CARMONETTE terrain was characterized as square pillars of varying sizes. It consisted of horizontal square surfaces whose elevations were that of their centroid (the center of the grid). The DYNTACS-X terrain representation, on the other hand, is composed of uniformly sized and shaped interconnected triangles whose end points are at varying elevations. Thus, the surfaces of the triangles can be oriented in virtually any plane, providing a multifaceted topography. This triangular representation provides a more realistic representation of the terrain contours. As a result, the improved terrain line-of-sight algorithms are considered to be more realistic.

(b) An expanded data base. The modification achieved compatibility between CARMONETTE and an extensive terrain data base developed at CACDA over the past few years. Data are available on disk-based files at TRADOC DPFO, Fort Leavenworth for the European V and VII Corps areas, North German plains, and selected Asian areas. With the exception of vehicle mobility measures, the CARMONETTE land deck data elements can be derived from this digital topographic data base.

e. CARMONETTE Data Base.

(1) Weapons effects data base. The CARMONETTE data base contains weapon characteristics and performance data. The source for all effects data is AMSAA/BRL. Performance data are provided for both Blue and Red in the attacking and defending position (e.g., Blue fully exposed with Red hull defilade).

(a) Direct fire weapon accuracy data are provided in fixed biases and round dispersions for first round fires (stationary and 30° crossing angle moving targets) and probability of subsequent round hits given a hit and given a sensed miss. Add-on dispersions are also provided for moving firers. The probability of kill (M/F) given a hit data are provided in 1-foot dispersions.

(b) Indirect fire weapon data were generated from AMSAA lethality and vulnerability source data by processing the AMORES Indirect Fire Model (AIFM). A complete description of the data sets and their development is contained in USACACDA TP 3-78, Indirect Fire Data for DRE Battalion Gaming Study.

(2) CARMONETTE land deck. The CARMONETTE land deck is composed of terrain elevation, vegetation height, cover index, concealment index, cross country mobility index, and road mobility index encoded for each 100-meter grid cell of the modeled terrain area. Processing of specific data items for DRE CARMONETTE runs are described in the following subparagraphs.

(a) Terrain elevation. Standard Defense Mapping Agency Topographic Center (DMATC) terrain elevations to the nearest meter above sea level were used.

(b) Vegetation height. Standard DMATC four level feature code to the nearest meter above terrain surface were used. Codes correspond to no vegetation (0-meter height), crops/orchards (3-meter height), buildings (7-meter height), and forestation (12-meter height).

(c) Cover index. Cover index for each terrain grid cell was derived by placing a target at the center of the grid and sampling potential observer positions within a predefined range band from the target. For each observer, the fraction of the target covered by terrain feature was computed and the grid assigned an index based on the coverage class interval into which the fraction falls. Cover indices may assume values from 1 to 15. It is important to note that cover fraction is only computed where observer to target intervisibility exists.

(d) Concealment index. Concealment index was assigned to grid cells by a process similar to that used for cover index. The exception was that only terrain features (crops, forests, and buildings) can provide concealment to a target, a condition independent of target cover. Concealment indices may likewise assume values from 1 to 15 indicating increasing degrees of concealment. A more detailed derivation of CARMONETTE land deck data is presented in reference 3.

(e) Cross country mobility (CCM) index. The CCM index was derived from the Combined Arms Tactical Training Simulator (CATTS) cross country movement data prepared by DMATC. Acetate overlays for the CATTS data were digitized for the DRE gaming areas and the original indices 1 through 7 regrouped into CARMONETTE indices 1 through 3. The CATTS overlay provides predicted maximum speed for M60, M113, M151, M35, and troops in cross country movement. Movement speeds used in DRE correspond to tactical mobility speeds for the specific systems simulated.

(f) Road mobility index. A two level road mobility index was assigned each terrain grid cell. Zero indicates no road and 1 indicates the presence of a road. Data for road mobility were digitized directly from 1:50,000 DMA maps considering only autobahn through secondary road quality.

(3) Mobility data. The mobility data were derived from the results of the DRE Battalion Field Test held at TCATA (reference 2). In this test, data were gathered on the tactical maneuvering speeds of M60A1s and M113s (TOW) configured as T-series and H-series platoons. Estimates were then made from these speeds for the expected tactical mobility rates of the 1985 Blue weapon systems -- XM1, IFV/CFV and ITV.

A detailed description of the method used to extrapolate these 1985 weapon system tactical mobility rates and how they were applied to this study is at appendix A.

(4) Sensor data. The CARMONETTE sensor data used in this study were the same used by CAA in the AAH study. Since in the DRE scenarios the primary means for the gathering of intelligence and target acquisition were eyeballs (aided and unaided), it was decided to use the CAA sensor data.

(5) Other data. The remainder of the data base (UNT cards) varied among the scenarios that were gamed. The UNT cards describe each unit including weapons and orders. A detailed description of the CARMONETTE data base requirements can be found in book II of the GRC documentation (reference 1).

f. CARMONETTE Postprocessors. In addition to the postprocessor inherent to CARMONETTE, statistical and battle graphic postprocessors were developed by CACDA to augment CARMONETTE for this study. These new postprocessors use the output from the CARMONETTE battle model known as the "history file."

(1) Statistical postprocessor. The new statistical postprocessor was developed as a series of programs and routines to compute from the history file the measures of combat effectiveness and the measures of individual weapon system performance presented in paragraph 9 and to conduct the statistical analysis described in paragraph 11. Graphics programs to display the measures of effectiveness/ performance as functions for time for selected organizations/weapon systems were also developed.

(2) CARMONETTE battle graphic postprocessor.

(a) The graphic postprocessor developed during this study displays the combat actions simulated during a CARMONETTE run. Information on the history file records is processed and displayed on a TEKTRONIC 4081 graphic terminal. The actions of combat displayed by the graphic postprocessor include the following:

1. Unit movement.

2. Direct fire pairings.

3. Artillery/mortar firings.

4. Casualty assessment.

5. Mount/dismount of passengers from carrier units.

(b) The terrain background may be viewed in the form of various overlays, which include a grid, contour lines, and forested and built-up areas. The grid covers a 6500x6500-meter area and is divided into 500- meter squares. The terrain contours are lines of constant terrain elevation. The contour interval used for this study was 20 meters. The contour interval may be changed, but it requires a new set of data. The forest and built-up area overlay simply depicts each 100-meter square grid that contains trees and/or buildings. These terrain overlays can be viewed individually or collectively.

(c) A feature of the graphics postprocessor is the capability to "zoom-in" or expand a small portion of the battle area. The display area may be changed in 100-meter increments from the standard 6500-meter square down to the resolution of a 100-meter square. Thus, any section of the battle area may be displayed at full screen scale.

(d) Additional features of the CARMONETTE battle graphics postprocessor include the ability to start the display at any point of time during the battle and view it for any length of time until battle termination. Another feature is the capability to display the movement trails for all units at any point in the battle and to display the positions at which vehicles were lost and units were killed. The postprocessor also can display all fire pairings by type weapon system at any point in the battle.

(e) The CARMONETTE battle graphics postprocessor was developed at CACDA by members of the DRE battalion gaming study team. The documentation for the graphics postprocessor is currently under development and will be published by CACDA.

7. ALTERNATIVE ORGANIZATIONS.

a. General. The Blue organizations evaluated in this study were derived from the current (H-series) and the future alternative (T-series) battalion task forces. All organizations were evaluated in the 1985 time frame by updating their present TOE with the weapon systems whose IOC dates are within the specified time frame. The future Blue weapon systems included in these organizations are the following:

(1) XM1 tank.

(2) Infantry fighting vehicle (IFV).

(3) Cavalry fighting vehicle (CFV).

(4) Improved TOW vehicle (ITV).

b. Basis for Comparison. Meaningful comparisons in force structure studies require a certain level of consistency between the organizations being compared and the scenarios in which they are being compared. Normally, in studies that compare similar alternative force structures, it is sufficient to hold the initial force ratios constant. However, the sizes of the organizations being compared in this study were significantly different.

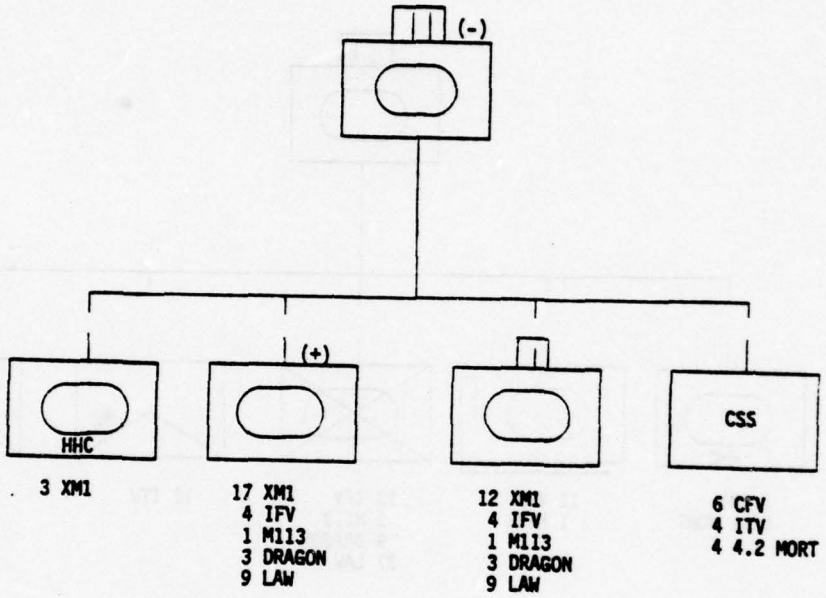
(1) Considering major weapon systems, an H-series battalion task force is larger (about 50 percent larger) than a T-series battalion task force. Thus, in order to maintain constant initial force ratios, the Red force opposing the H-series organizations would have to be half again larger than the Red force opposing the T-series organizations. In addition, the larger H-series battalion requires a larger unit frontage upon which to deploy its weapons. Accordingly, if full H-series and T-series battalions were compared, it would be impossible to determine whether any measured differences in effectiveness and performance were attributable to differences in the number of major weapon systems, differences in unit frontages, differences in threat forces, or differences in organization.

(2) A basis for comparison was achieved in this study by reducing the size of the H-series organizations being compared so that they contained approximately the same number of major weapon systems as the T-series organizations. The number of weapon systems could be only approximately the same between the organizations because it was necessary to maintain unit integrity to the degree possible. This allowed the organizations being compared to be deployed over equal frontages on the same terrain and to be opposed by an identical threat in their respective scenarios.

c. Blue Battalion Task Forces. The H-series and T-series tank heavy and mech heavy battalion task forces gamed in this study are presented in figures 1 through 4. Due to CARMONETTE limitations (specifically, that aggregate units must be homogeneous), some modifications were made to the number and type of weapon systems in the Blue task force organizations. For example, the H-series tank heavy battalion task force headquarters and headquarters company (HHC) contains three XM1s and one M113. The battalion headquarters was represented in the CARMONETTE gaming as one unit consisting of three XM1s only. In the mech organizations it was necessary, in some cases, to equate M113s to IFVs. The scouts in all organizations had to be updated fom M113/TOWs and M113s to CFVs.

8. SCENARIOS.

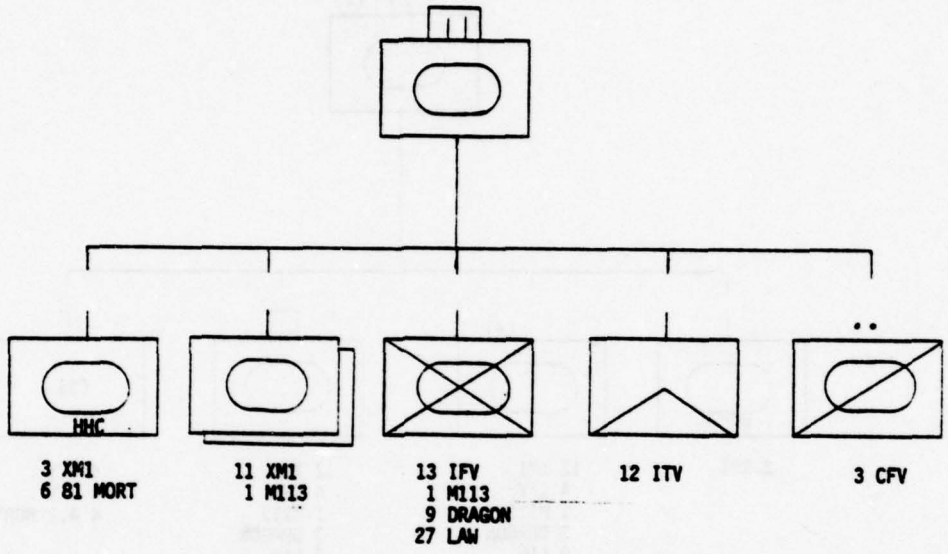
a. General. Each alternative organization was evaluated in offensive and defensive scenarios. The two tank organizations were also evaluated in an additional defensive scenario in a covering force area.



TOTALS

32 XM1
8 IFV
6 CFV
4 ITV
2 M113
52 VEHICLES

Figure 1. H-series tank heavy battalion task force.

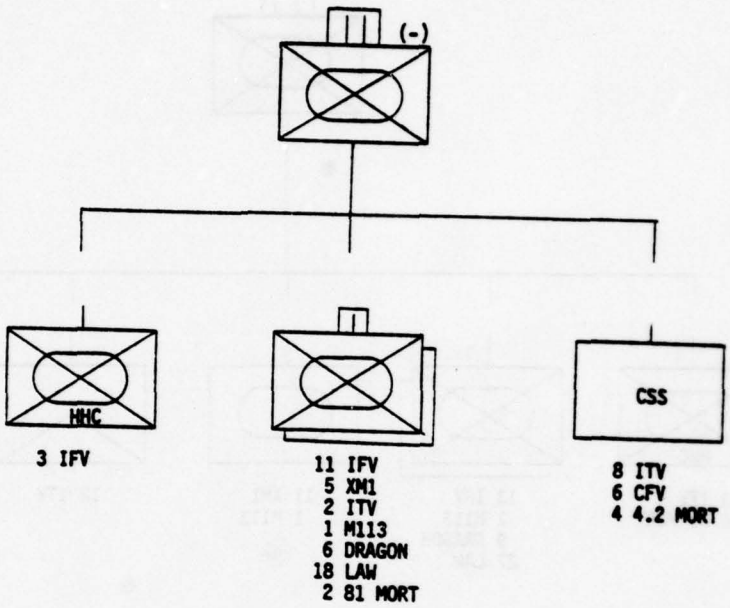


TOTALS

25 XM1
13 IFV
3 CFV
12 ITV
3 M113

56 VEHICLES

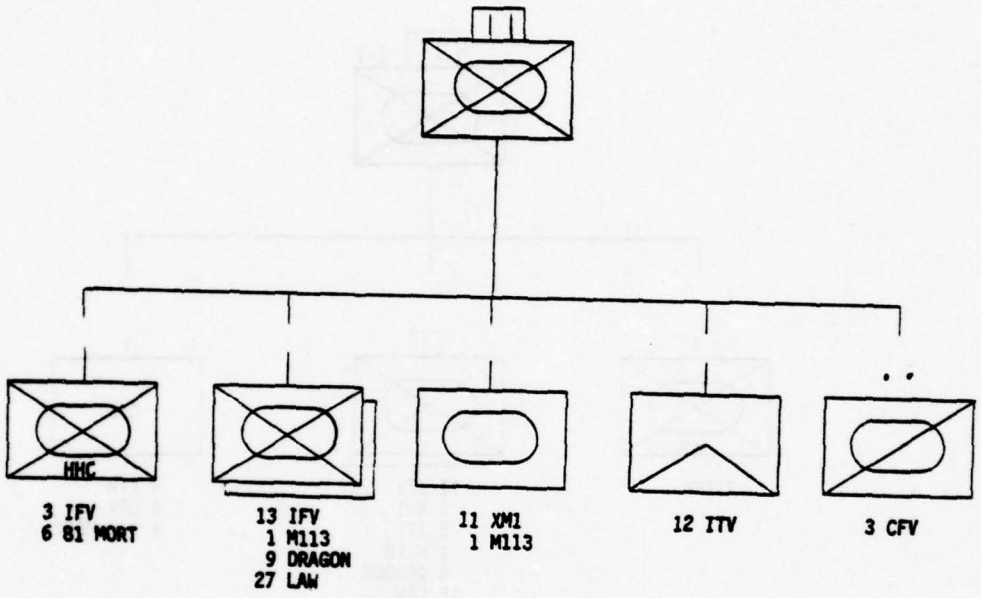
Figure 2. T-series tank heavy battalion task force.



TOTALS

10 XM1
25 IFV
6 CFV
12 ITV
2 M113
55 VEHICLES

Figure 3. H-series mech heavy battalion task force.



TOTAL

11 XM1
29 IFV
3 CFV
12 ITV
3 M113
58 VEHICLES

Figure 4. T-series mech heavy battalion task force.

Each of the three scenarios is discussed briefly below. A more detailed discussion of the scenarios, which includes the battle situations, terrain analyses, initial deployment of the forces, and narratives of the battles fought by each alternative organization, is presented in appendix B.

b. Position Defense Scenarios. In this scenario each of the four alternative Blue organizations occupied battle positions on the Fulda River between the towns of Niederjossa and Niederaula. They were attacked by a Red motorized rifle regiment (MRR) attempting to conduct a river crossing across the Fulda. Since there is little movement by the Blue forces, this scenario stressed each organization's ability to service targets in a target rich environment.

c. Deliberate Attack Scenarios. All four alternative organizations were also evaluated, in turn, in an offensive scenario, which arrayed them against a Red motorized rifle company reinforced with a tank platoon. The Red weapon systems took up battle positions in the vicinity of Arzell-Eiterfeld. This scenario was developed to evaluate each organization's ability to maneuver its weapon systems to bring as much of its firepower as possible to bear against the enemy.

d. Covering Force Action Scenarios. The two tank organizations were evaluated conducting an active defense in the covering force area (CFA). These actions, also occurring in the vicinity of Arzell-Eiterfeld, placed an MRR conducting a road march through the CFA against each of the two tank organizations. The Blue weapon systems initially engaged the lead elements of the MRR, to make it deploy from the road march, and then fought brief delaying actions to inflict as much damage as possible on the Red force without becoming decisively engaged. This scenario also stressed an organization's ability to maneuver its firepower.

9. ESSENTIAL ELEMENTS OF ANALYSIS AND MEASURES OF EFFECTIVENESS AND PERFORMANCE.

a. Essential Elements of Analysis (EEA). Two EEA were addressed in this study, as follows:

(1) EEA 1. What is the relative effectiveness of a battalion task force derived from the alternative heavy division as compared to one derived from the current organization?

(2) EEA 2. What is the contribution of each major direct fire weapon system to the overall difference in effectiveness?

b. Measures of Effectiveness (MOE) and Measures of Performance (MOP). The MOE and MOP that were used to evaluate the two EEA are presented below. The overall combat effectiveness measures were used in

the evaluation of EEA 1, and the direct fire effectiveness and performance measures were used to evaluate EEA 2. In the determination of the MOE and MOP a weapon system (and a loss) was defined as one of the major direct fire weapon systems. The Blue major direct fire weapon systems were XM1, ITV, IFV, CFV, and M113; the Red major direct fire weapons systems were T72, BMP, and BRDM-2. Although many of the following expressions are actually MOP, they are all referred to as MOE.

(1) Overall combat effectiveness measures.

(a) MOE 1. Total (cumulative) Red losses (RL).

(b) MOE 2. Total (cumulative) Blue losses (BL).

(c) MOE 3. Loss exchange ratio (LER), where:

$$LER = \frac{\text{Red losses}}{\text{Blue losses}}$$

(d) MOE 4. Surviving maneuver force ratio differential (SMFRD), where:

$$SMFRD = \frac{\text{Blue surviving weapons}}{\text{Blue initial weapons}} - \frac{\text{Red surviving weapons}}{\text{Red initial weapons}}$$

(e) MOE 5. Time (in minutes) to battle termination.

(2) Direct fire effectiveness and performance measures.

(a) MOE 6. Killer-victim scoreboards.

(b) MOE 7. Blue kth type direct fire weapon LERs (LER_k), where:

$$LER_k = \frac{\text{Red losses to Blue kth type weapon}}{\text{Blue kth type weapon losses}}$$

(c) MOE 8. Percent of Red losses attributable to Blue kth type weapons (percent RL_k).

(d) MOE 9. Blue kth type weapon loss ratio (WLR_k), where:

$$WLR_k = \frac{\text{Blue kth type weapon losses}}{\text{Initial number of Blue kth type weapons}}$$

(e) MOE 10. Blue kth type weapon engagement rate (WER_k), where:

$$WER_k = \frac{\text{Number of Blue kth type weapon firings}}{\text{Combat interval (minutes)}}$$

(f) MOE 11. Blue kth type weapon effective firepower percentage (EFP_k), where:

$$EFP_k = \frac{\text{Number of Blue kth type weapons that fired}}{\text{Initial number of Blue kth type weapons}} \times 100.0$$

(g) MOE 12. Average engagement range of Blue kth type weapon (AER_k).

10. RUN DESIGN.

a. General. The run design for this study was developed to address all factors considered necessary to investigate the EEA. It was developed with the intention of being executed with CARMONETTE as the combat simulator. The DRE battalion gaming CARMONETTE run design is presented in table 1.

b. Definitions.

(1) Design factor. The independent variables of the run set.

(2) Replication. One successful execution of the CARMONETTE model.

(3) Run. One or more replications that hold the input data constant and vary only the random number seed.

(4) Run set. One or more runs that vary the design factors of the input data in a prescribed manner.

c. Design Factors. The design factors that were varied among the run sets are presented and discussed below.

(1) Task force. This study evaluated two types of maneuver organizations:

(a) Armor - tank heavy battalion task force.

(b) Mech - mechanized infantry heavy battalion task force.

(2) Organization. Two alternative organizational structures were evaluated in this study:

Table 1. DRE battalion gaming CARMONETTE run design.

Design Factor	Run Set*		
	1	2	3
Task Force Armor (A) Mech (M)	2	2	A
Organization H-series (H) T-series (T)	2	2	2
Mission Position Defense (PD) Deliberate Attack (DA) Covering Force Action (CFA)	PD	DA	CFA
Terrain Area 1 (A1) Area 2 (A2)	A1	A2	A2
CARMONETTE RUNS	4	4	2

*A numeric 2 implies that both values of the design factor were used in the run set.

(a) H-series - organization derived from the current armor division TOE.

(b) T-series - organization derived from the restructured heavy division TOE.

(3) Mission. The battalion task force organizations were evaluated in three different types of scenarios:

(a) Position defense - the mission of the Blue force was to defend in position against an attempted river crossing by the Red force.

(b) Deliberate attack - the mission of the Blue force was to conduct a deliberate attack to secure specified objectives.

(c) Covering force action - the mission of the Blue force was to delay and engage the Red force in the covering force area by destroying his recon screen and forcing deployment.

(4) Terrain. The alternative organizations were evaluated on two types of European terrain:

(a) Area 1. German terrain bordered in the north by the city of Nederaula and in the south by Niederjossa. The area is bisected by the Fulda River and not considered good track country.

(b) Area 2. This area is typical of rolling German terrain; it is good track country. This terrain is in the general vicinity of the cities of Arzell-Eiterfeld.

d. Run Sets. The run sets of the CARMONETTE run design were set up to evaluate the alternative organizations over a variety of missions in two types of European terrain.

(1) Run set 1. This run set evaluated the alternative tank and mech organizations in a position defense conducted against the Red force attempting to cross the Fulda river in terrain area 1. Since there is little movement by the Blue force, this scenario stresses the ability of the Blue force to service Red targets effectively and quickly.

(2) Run set 2. The second run set was designed to measure the performance and evaluate the effectiveness of the alternative organizations while conducting offensive operations. These scenarios, conducted in terrain area 2, tested each Blue organization's ability to maneuver and bring its firepower to bear on the Red force.

(3) Run set 3. The last run set was developed to evaluate the Blue force task organizations in a covering force operation. These scenarios were also developed in the rolling terrain of area 2 and also stressed the ability of the Blue organizations to maneuver their firepower against the Red force.

11. ANALYSIS METHODOLOGY. Termination of each replication of CARMONETTE resulted in several MOE/MOP that indicated the performance of the organizations gamed. Because of the dependent relationships existing among these MOE/MOP and the desire to reduce the study-wide type 1 error (which is the probability of rejecting a true null hypotheses) through reducing the number of hypotheses tested, multivariate statistical procedures rather than univariate procedures were applied where appropriate. The major multivariate technique applied was Hotelling's T^2 test. This test indicates a difference if it exists between the vectors of means taken from two groups. For example, to address the question of an overall difference existing between the H and T-series, a vector of sample MOE/MOP means characterizing the overall combat effectiveness of the T-series organization was tested against the corresponding vector of sample MOE/MOP means from the H-series organization.

a. Issues, Questions, and Methodology. The following subparagraphs identify the EEA, issues, and questions addressed in the comparison of the gamed H and T-series tank/mech organizations. Also indicated is the procedure used for evaluating each issue.

(1) EEA 1 was stated in paragraph 9 as:

- What is the relative effectiveness of a battalion task force derived from the restructured division as compared to one derived from the current organization?

Operationally, to analyze this EEA for the situation gamed, this question was posed as:

- Is there a significant difference between the H and T-series tank/mech organizations in their overall effectiveness to fight an identical threat?

Originally, four MOE/MOP were considered to evaluate this question in the position defense and deliberate attack scenarios, where Red losses (RL) was used as the battle termination criterion.

These MOE/MOP were:

- Blue losses (BL).
- Loss exchange ratio (LER).
- Surviving maneuver force ratio differential (SMFRD).
- Time to battle termination (TIME).

As can be expected from the derivation, examination of the correlations existing among these MOE/MOP for the gamed situations indicated that BL, LER, and SMFRD were so highly intercorrelated that they were actually measuring the same attribute. For this reason, BL and SMFRD were eliminated as measures of overall effectiveness and LER and TIME were retained for statistical analysis. Similarly, in the covering force action where time was the battle termination criterion, BL and RL were retained for statistical analysis. For each situation gamed the null hypothesis:

$$H_0: \begin{bmatrix} \overline{LER}_T \\ \overline{TIME}_T \end{bmatrix} - \begin{bmatrix} \overline{LER}_H \\ \overline{TIME}_H \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix},$$

was tested against its alternative:

$$H_A: \begin{bmatrix} \overline{LER}_T \\ \overline{TIME}_T \end{bmatrix} - \begin{bmatrix} \overline{LER}_H \\ \overline{TIME}_H \end{bmatrix} \neq \begin{bmatrix} 0 \\ 0 \end{bmatrix},$$

using Hotellings T^2 test with $\alpha = .10$. When the null hypothesis was rejected, simultaneous 90 percent confidence intervals were constructed for the mean differences occurring between the corresponding pairs of MOE/MOP means. Such confidence intervals indicate the degree of difference existing for the particular MOE/MOP and which organization displayed the higher mean value. A specific description of Hotelling's T^2 procedure and the construction of simultaneous confidence intervals is provided in paragraph 11b.

(2) EEA 2 was stated in paragraph 9 as:

- What is the contribution of each major direct fire weapon system to the overall change in effectiveness?

In order to analyze this EEA for the T and H-series tank/mech organizations gamed, three separate issues were addressed for the direct fire weapon systems:

- ability of Blue direct fire weapon systems to destroy Red vehicles
- difference in types of Red kills inflicted
- differences in the survivability of the Blue direct fire weapon systems.

These three issues were posed as separate questions and treated with separate but similar methodologies.

(a) Issue 1 considers the ability of Blue direct fire weapon systems to destroy Red vehicles. The Red vehicles were defined as tanks, BRDMs, and BMPs; and the Blue weapon systems were defined as tank and TOW vehicles. In the preliminary analysis of the data, when the TOW vehicles were delineated by type (ITV, CFV, IFV), several statistically significant results were found. However, further analysis indicated several of these significant results were due to terrain and the positioning of the different TOW weapon types. For example, in one organization the ITVs might be positioned in forward positions with the best fields of fire, whereas in the alternative organization the ITVs might be assigned to an overwatch mission with CFVs and IFVs occupying the forward positions. Because of the interchangeability of TOW weapon systems across organizations and scenarios and the resulting influence on apparent effectiveness, the TOW weapon systems were grouped into a single class for analysis. On this basis, Issue 1 was stated as the following question:

- Issue 1. Is there a significant difference between the ability of Blue tanks and TOW vehicles from the H and T-series tank/mech organizations to destroy Red vehicles?

The two MOE/MOP used to evaluate this question were: (1) Red losses due to Blue tanks, and (2) Red losses due to Blue TOW vehicles. For each situation gamed, Hotelling's T^2 test with $\alpha = .10$ was used to test the equality of mean vectors from the two organizations. If the null hypothesis was rejected, simultaneous 90 percent confidence intervals were constructed to identify differences in the individual MOE/MOP from the two organizations. Provided the null hypothesis was rejected, the question of interest then became:

- Sub-Issue 1.1. Did the differences result from the different weapon systems mixes of the two organizations or did the difference result from different contributions by weapon systems?

In order to address this sub-issue, average Red losses per weapon system were considered; that is, for each replication the Red losses due to tanks and TOWs were divided by the original number of tanks and TOW

vehicles for the respective organizations. The resulting mean vectors were checked for significance by organization. At this point a significant result indicated a difference in contribution of the weapon systems between the two organizations. In this event, five weapon systems MOE/MOP were examined:

- Weapon system loss exchange ratio.
- Percent of Red losses per weapon.
- Weapon engagement rate.
- Effective firepower percentage.
- Average engagement range.

Differences among these weapon MOE/MOP were used to infer the manner in which the weapon systems were contributing differently within the two organizations.

(b) The second issue addressed the type of Red kills inflicted. The different types of kills were defined as kills of Red tanks, BRDMs, and BMPs. For testing, this issue was stated as the following question:

- Issue 2. Is there a significant difference in the average number of Red tank, BRDM, and BMP kills inflicted by the H and T-series tank/mech organizations?

Hotelling's T^2 test with $\alpha = .10$ was used to test the equality of the mean vectors of Red tank, BRDM, and BMP kills inflicted by the Blue organizations gamed. This test was carried out in a manner analogous to those previously described, with the construction of simultaneous confidence intervals in the event significance was found.

(c) The remaining issue addressed under EEA 2 concerned the survivability of the Blue direct fire weapon systems. As with Issue 1, the weapon systems were defined as Blue tanks and TOW vehicles. The question of survivability was stated as:

- Issue 3. Is there a significant difference in the survivability of the Blue tanks and TOW vehicles from the H and T-series tank/mech organizations when pitted against an identical threat?

As with the preceding issues, the analysis was performed using Hotelling's T^2 test. If the null hypothesis was rejected, simultaneous 90 percent confidence intervals were formed to identify differences in

the individual MOE/MOP from the gamed organizations. When a significant difference was found, the question of interest became:

- Sub-Issue 3.1. Did the difference exist due to different weapon systems mixes of the two organizations or did the difference result from different contributions by the weapon systems?

To address this sub-issue the survivability per Blue original weapon was considered. From this point on, the methodology paralleled that developed with Sub-Issue 1.1 in determining if the differences resulted from weapon system mixes or from different contributions of the weapon systems. Again the remaining five MOE/MOP for each weapon system were examined if weapon systems were found to be contributing differently.

b. Hotelling's Two Sample T^2 Statistic. Suppose that independent random samples of observations on p variables of interest have been obtained under different conditions from two groups. Also assume in each condition:

- The variables have a multivariate normal distribution.
- The same, though unknown, covariance matrix Σ of full range p exists.

A test of the null hypothesis:

$$H_o: \begin{bmatrix} \mu_{11} \\ \mu_{12} \\ \vdots \\ \mu_{1p} \end{bmatrix} = \begin{bmatrix} \mu_{21} \\ \mu_{22} \\ \vdots \\ \mu_{2p} \end{bmatrix}$$

that the population mean vectors of the p variables are equivalent, as opposed to the alternative hypothesis:

$$H_A: \begin{bmatrix} \mu_{11} \\ \mu_{12} \\ \vdots \\ \mu_{1p} \end{bmatrix} \neq \begin{bmatrix} \mu_{21} \\ \mu_{22} \\ \vdots \\ \mu_{2p} \end{bmatrix}$$

can be performed. Compute the sample mean vectors:

$$\bar{X}_1 = \begin{bmatrix} x_{11} \\ x_{12} \\ \vdots \\ x_{1p} \end{bmatrix}, \quad \bar{X}_2 = \begin{bmatrix} x_{21} \\ x_{22} \\ \vdots \\ x_{2p} \end{bmatrix}$$

and the pooled covariance matrix:

$$S = \frac{1}{n_1 + n_2 - 2} (A_1 + A_2)$$

where n_1 and n_2 are the number of observations taken from each group and A_1 and A_2 are the sum of squares cross products matrices for the two groups. Given X_i, the p x n_i matrix of observations from the i-th group, and $\bar{X}_i$, the matrix of means (i.e., each row contains the mean values on the pth variates), the sum of squares cross products matrix A_i is given by:

$$A_i = (X_i - \bar{X}_i)' \cdot (X_i - \bar{X}_i)$$

The T^2 statistic is computed as:

$$T^2 = \frac{n_1 \cdot n_2}{n_1 + n_2} (\bar{X}_1 - \bar{X}_2)' S^{-1} (\bar{X}_1 - \bar{X}_2)$$

The decision process is to accept H_0: $\mu_1 = \mu_2$ if

$$T^2 \leq \frac{(n_1 + n_2 - 2) \cdot p}{n_1 + n_2 - p - 1} F_{\alpha;\, p,\, n_1+n_2 - p - 1}$$

and reject otherwise. Here, F represents the tabled F statistic with significance level α and degrees of freedom p and (n_1+n_2-p-1). The 100 $(1-\alpha)$ percent joint confidence region is specified by the vector δ satsifying the inequality:

$$(\bar{X}_1 - \bar{X}_2 - \delta)' S^{-1} (\bar{X}_1 - \bar{X}_2 - \delta) \leq \frac{n_1 + n_2}{n_1 \cdot n_2} T^2_{\alpha;\, p,\, n_1+n_2 - p - 1}$$

where,

$$T^2_{\alpha;\, p,\, n_1+n_2-p-1} = \frac{(n_1+n_2-2)p}{(n_1+n_2-p-1)} F_{\alpha;\, p,\, n_1+n_2-p-1}$$

Similarly, the 100 (1-α) percent simultaneous confidence intervals for all linear contrasts $a' \delta$ of the mean differences are defined by:

$$a' (\bar{X}_1 - \bar{X}_2) - \sqrt{a'Sa \frac{n_1+n_2}{n_1 \cdot n_2} T^2_{\alpha;\, p,\, n_1+n_2-p-1}} \leq a' \delta$$

$$\leq a' (\bar{X}_1 - \bar{X}_2) + \sqrt{a'Sa \frac{n_1+n_2}{n_1 \cdot n_2} T^2_{\alpha;\, p,\, n_1+n_2-p-1}}.$$

Further explanation of Hotelling's T^2 statistic is available in references 4 and 6.

c. Adequacy of Hotelling's T^2 Test. As is typical in practical applications of statistical procedures, the analyzed data sets were assumed to fulfill the basic assumptions required by the test statistic. Since all data sets violate such assumptions to some extent, it is worthwhile to review the effects of violating these assumptions to determine their practical importance. The following discussion indicates that the effects of violating the assumptions of multivariate normality and equality of covariance matrices with regard to Hotelling's T^2 statistic are minimal. Also, as a matter of practical import, the power of Hotelling's T^2 is discussed.

(1) The assumption of multivariate normality in T^2 is a direct extension of the assumption of normality in the univariate t-test. Harris (reference 5, p. 81) reported that little is known about the robustness of T^2, except that for sufficiently large sample sizes, computed T^2-values do conform to the F-distribution, regardless of the shape of the parent population. Lacking, however, are empirical sampling studies to determine just how large the sample sizes need to be. In view of this, Harris stated:

> ...might suspect from multitude of empirical sampling experiments which have demonstrated the remarkable robustness of Student's t-test against violations of the normality assumption, that violation of multivariate normality would have similar small effects on the validity of T^2-tests unless especially "wild" distributions are employed.

(2) According to Morrison (reference 6, p. 152-153), Ito and Schull investigated the effects of unequal covariance matrices on the true α and power probabilties while using the T^2-statistic. They showed that the true significance level and power are unaffected by discrepancies between the covariance matrices when the sample sizes are equal and fairly large.

(3) For the two-sample test of equality of mean vectors, the T^2 statistic of paragraph 11b has the noncentral F distribution with parameter:

$$\delta^2 = \frac{n_1 \cdot n_2}{n_1 + n_2} (\mu_1 - \mu_2)' \Sigma^{-1} (\mu_1 - \mu_2)$$

and degrees of freedom p and $n_1 + n_2 - p - 1$. Charts of the power function of the noncentral F have been prepared for tests of size .05 and .01 and certain degrees of freedom. However, no such charts have been located for α = .10 and corresponding to the noncentral parameters estimated from the trial DRE runs. Rather than spending considerable time calculating values and preparing charts of the power function of the noncentral F, the power of univariate t-tests was used to infer roughly the power of the T^2 tests. Morrison (reference 6, p. 150-152) explored the relationship existing between univariate and multivariate powers for a single-sample test with two means. He noted that the T^2 test had appreciably less power than the univariate t-tests when the correlations were near zero. However, as the absolute value of the correlation increases, the multivariate power eventually surpassed that of the univariate test.

12. RESULTS. Based on the resulting MOE/MOP from 25 replications of CARMONETTE for each organization and scenario combination, inferential statistics between the corresponding T-series and H-series organizations as well as summary statistics for each organization were computed. Five separate organizational comparisons were performed according to the methodology described in the preceding paragraph. Specifically, these comparisons were:

- H-series versus T-series tank organizations in a position defense.
- H-series versus T-series mech organizations in a position defense.
- H-series versus T-series tank organizations in a deliberate attack.
- H-series versus T-series mech organizations in a deliberate attack.
- H-series versus T-series tank organizations in a covering force action.

Details of these scenarios were discussed in paragraph 8. Results of the aforementioned comparisons are presented in the remainder of this paragraph.

a. Tank Organizations in Position Defense.

(1) As indicated in the methodology, the overall effectiveness (EEA 1) of the two organizations was evaluated using loss exchange ratio (LER) and time for battle termination (TIME) as dependent variables with Hotelling's T^2 as the test statistic. Table 2 displays the dependent variable means and standard deviations by organization. A significant T^2 value of 26.69 ($p < .001$) was obtained. ($p < .001$ means that the probability of attaining a computed T^2 value of this magnitude by chance alone is less than .001.) Therefore, the null hypothesis of equivalent mean vectors was rejected. This being the case, the 90 percent simultaneous confidence intervals for mean differences were constructed. The obtained confidence intervals were:

$$-1.98 < \overline{LER}_T - \overline{LER}_H < -.39$$

and:

$$.63 < \overline{TIME}_T - \overline{TIME}_H < 1.61.$$

These results indicate on the average the H-series tank organization achieved a higher LER and terminated the battle quicker than the T-series tank organization.

Table 2. Overall effectiveness means and standard deviations for tank organizations in position defense.

MOE/MOP	Observations Per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
LER	25	3.01	.63	4.20	1.68
TIME (Min)	25	24.28	.72	23.16	.82

(2) The first issue addressed with regard to EEA 2 concerned the ability of Blue tanks and TOW vehicles to kill Red vehicles. The average number of kills achieved by these systems is shown in table 3. The computed statistic ($T^2 = 110.70$) verified the quite apparent difference in mean vectors. To determine if the observed differences were due to weapons systems mix or differential contributions by weapon systems, the average number of kills per original weapon system was computed. These results are displayed in table 4. A computed T^2 value of 14.13 ($p < .01$) indicated the average number of kills per weapon system were not equivalent for the two organizations. The 90 percent confidence intervals for the differences on a per weapon system basis are:

$$-.33 < \bar{X}_{Ttk} - \bar{X}_{Htk} < -.07$$

$$-.12 < \bar{X}_{Ttow} - \bar{X}_{Htow} < .12.$$

As indicated by the symmetric confidence interval about zero, the TOW weapons demonstrated no per weapon difference between the two organizations. However, the confidence interval for tanks indicated a better performance by the H-series tank than the T-series tank on a per weapon basis. The MOE/MOP characterizing the tank performance of the two organizations are presented in table 5.

Table 3. Means and standard deviations of Red vehicle kills for tank organizations in position defense.

MOE/MOP	Observations Per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses to Tanks	25	45.28	5.73	64.36	9.57
Red Losses to TOWs	25	46.72	6.38	30.04	5.06

Table 4. Means and standard deviations of Red vehicle kills per weapons system for tank organizations in position defense.

MOE/MOP	Observations Per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses per Tank	25	1.81	.23	2.01	.30
Red Losses per TOW	25	1.67	.23	1.67	.28

Table 5. Means and standard deviations of the MOE/MOP for tank weapons from the tank organizations in position defense.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	3.82	1.44	4.72	1.79
Percent Red Losses per Weapon	25	2.54	.36	2.72	.30
Weapon Engagement Rate (rds/min/wpn)	25	1.34	.13	1.24	.14
Effective Firepower Percentage	25	86.86	3.45	84.14	3.73
Average Engagement Range	25	2119.66	46.03	1857.22	46.05

(3) The second issue underlying EEA 2 focused on the type of Red vehicle kills inflicted by Blue weapon systems. Table 6 shows that the average number of Red tank, BRDM, and BMP kills did not differ a great deal in the T-series and H-series replications. Statistically this was demonstrated by a failure to reject the null hypothesis of equivalent mean vectors at the $\alpha = .10$ level.

Table 6. Mean and standard deviation of Red kills by type for tank organizations in position defense.

MOE/MOP	Observation per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	18.76	1.01	19.40	1.44
BRDMs	25	8.24	1.17	8.64	.81
BMP	25	66.60	4.52	67.00	5.70

(4) The remaining issue addressed in association with EEA 2 concerned the survivability of the Blue tanks and TOW vehicles. The average number of Blue losses by these weapons systems is exhibited in table 7. A significant T^2 value of 343.33 ($p < .001$) was obtained, and thus, in terms of average Blue losses by weapons system type, differences occurred. In order to determine the relative survivability of the weapons systems the Blue losses per original weapons system (i.e., proportions destroyed) were considered. Table 8 displays the average losses per original weapons system. In comparing the mean vectors of losses on a per weapons system basis, the value of T^2 was computed to be 12.36 ($p < .01$). In addition the 90 percent confidence intervals for differences were computed to be:

$$-.04 < \bar{X}_{Ttk} - \bar{X}_{Htk} < .13$$

$$.04 < \bar{X}_{Ttow} - \bar{X}_{Htow} < .22$$

As indicated by the exclusion of zero from the confidence interval for the TOW difference and near exclusion for the tank difference, disparities on a per weapon system basis existed. These results imply more TOW vehicles and tanks were destroyed on a per weapons system basis in the T-series than in the H-series. To aid in inferring possible causes for such results, MOE/MOP characterizing individual weapons system performance were calculated. Table 9 presents these MOE/MOP for the TOW vehicles, and table 5 previously presented the corresponding values for the tanks. The interpretation of these results as well as their synthesis with results from the remaining comparisons is presented in paragraph 13 of this report.

Table 7. Mean and standard deviations of Blue losses for tank organizations in position defense.

MOE/MOP	Observation per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	12.96	3.36	15.20	4.56
TOWs	25	19.44	2.62	10.24	3.22

Table 8. Mean and standard deviation of Blue losses per original weapons system for tank organizations in position defense.

MOE/MOP	Observation per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	.52	.13	.48	.14
TOWs	25	.69	.09	.57	.18

Table 9. Means and standard deviation of the MOE/MOP for TOW weapons from the tank organizations employed in position defense.

MOE/MOP	Observation per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	2.48	.64	3.36	1.70
Percent Red Losses per Weapon	25	2.64	.30	2.48	.70
Weapon Engagement Rate (rds/min/wpn)	25	.95	.10	.96	.12
Effective Firepower Percentage	25	94.36	1.98	97.25	5.44
Average Engagement Range	25	1905.76	41.83	1891.34	49.60

b. Mech Organization in Position Defense.

(1) As before, the overall effectiveness of the two organizations was evaluated using LER and TIME as dependent variables. The means and standard deviations of these variables are displayed in table 10. The null hypothesis of equivalent mean vectors was rejected since a significant T^2 value of 10.67 ($p < .01$) was calculated. The subsequent computation of the 90 percent simultaneous confidence intervals yielded:

$$.15 < \overline{LER}_T - \overline{LER}_H < 1.29$$

$$-1.15 < \overline{TIME}_T - \overline{TIME}_H < -.07$$

These intervals convey that on the average the T-series Mech organization attained a higher LER and terminated the battle quicker than the H-series Mech organization.

Table 10. Overall effectiveness means and standard deviations for mech organizations in position defense.

MOE/MOP	Observations Per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
LER	25	3.51	.77	2.79	1.03
TIME (min)	25	22.89	.53	23.50	1.10

(2) The demonstrated ability of the two organizations to destroy Red vehicles is presented in table 11. A computed test statistic value of 11.99 ($p < .01$) indicated a difference in the vectors of means. However, when the kills were determined on a per weapons system basis (table 12), the null hypothesis of equivalent mean vectors could not be rejected at the $\alpha = .10$ level. This implies the difference in vehicle kills resulted from the weapons system mixes rather than disproportionate contributions by weapons systems.

Table 11. Mean and standard deviations of Red vehicle kills for mech organizations in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses to Tanks	25	21.40	5.03	17.60	6.42
Red Losses to TOWs	25	73.12	5.01	67.28	10.48

Table 12. Mean and standard deviations of Red vehicle kills per weapons system for mech organizations in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses per Tank	25	1.95	.46	1.76	.64
Red Losses per TOW	25	1.66	.11	1.56	.24

(3) Table 13 exhibits the type of Red vehicle kills inflicted by Blue weapons systems. Since a T^2 value of 15.71 ($p < .01$) was obtained, the null hypothesis of equivalent mean vectors was rejected and 90 percent simultaneous confidence intervals computed. The resulting intervals were:

$$.39 < \bar{X}_{Ttk} - \bar{X}_{Htk} < 2.82$$

$$-.64 < \bar{X}_{Tbrdm} - \bar{X}_{Hbrdm} < .80$$

$$1.38 < \bar{X}_{Tbmp} - \bar{X}_{Hbmp} < 13.83$$

As indicated by the first and third confidence intervals, the T-series Mech was able to destroy more Red tanks and BMPs than the H-series Mech.

Table 13. Means and standard deviations of Red kills by type for mech organizations in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	19.16	1.34	17.56	1.87
BRDMs	25	8.56	.87	8.48	1.05
BMPs	25	67.44	2.86	59.84	11.46

(4) On the average, fewer Blue tanks and TOWs appear to be destroyed in the T-series Mech organization (table 14). Statistically this statement was verified by a computed T^2 value of 21.29 ($p < .001$). The relative survivabilities of the same weapons systems are displayed in table 15. On the per weapons system basis the null hypothesis of equivalent mean vectors was also rejected ($T^2 = 37.78$; $p < .001$). Subsequently, the 90 percent confidence intervals were computed to be:

$$-.37 < \bar{X}_{Ttk} - \bar{X}_{Htk} < -.16$$

$$-.14 < \bar{X}_{Ttow} - \bar{X}_{Htow} < .00$$

Table 14. Means and standard deviations of Blue losses for mech organizations in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	5.72	1.88	7.88	1.67
TOWs	25	23.32	4.34	25.84	5.52

Table 15. Means and standard deviations of Blue losses per original weapons system for mech organizations in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	.52	.17	.78	.17
TOWs	25	.53	.10	.60	.13

The exclusion or near exclusion of zero from both intervals implied a per weapons system difference for both tanks and TOWs. In each case, the T-series weapons systems survived relatively better than those in the H-series. As an aid for interpreting these results, the MOE/MOP characterizing tank and TOW achievements are presented in tables 16 and 17, respectively.

Table 16. Means and standard deviations of the MOE/MOP for tank weapons from the mech organizations employed in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	4.45	2.79	2.52	1.52
Percent Red Losses per Weapon	25	2.68	.61	3.20	.81
Weapon Engagement Rate (rds/min/wpn)	25	1.77	.21	1.37	.25
Effective Firepower Percentage	25	96.89	5.09	95.20	7.14
Average Engagement Range	25	2024.65	66.78	1921.13	65.45

Table 17. Means and standard deviations of the MOE/MOP for TOW weapons from the mech organizations employed in position defense.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	3.27	.79	2.80	1.03
Percent Red Losses per Weapon	25	2.30	.18	2.54	.30
Weapon Engagement Rate (rds/min/wpn)	25	.98	.08	.99	.07
Effective Firepower Percentage	25	94.78	2.17	94.19	2.95
Average Engagement Range	25	1993.34	35.90	1984.97	29.90

c. Tank Organization in Deliberate Attack.

(1) LER and TIME once again served as the MOE/MOP used to compare the overall accomplishments of the two organizations (table 18). A T^2 value of 39.67 ($p < .001$) indicated a difference did result in the average overall effectiveness measures. On the average the H-series organization was able to terminate the battle quicker; however, it achieved a lower LER. The 90 percent confidence intervals for the average difference were computed to be:

$$-.03 < \overline{LER}_T - \overline{LER}_H < .25$$

$$.06 < \overline{TIME}_T - \overline{TIME}_H < 1.43$$

Table 18. Overall effectiveness means and standard deviations for tank organizations in deliberate attack.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
LER	25	.88	.19	.76	.25
TIME	25	18.78	.86	18.04	1.27

(2) The ability of the tank and TOWs from the two organizations to kill Red vehicles is depicted in table 19. A test statistic of 26.65 confirmed the apparent difference in mean values. However, on a per weapons system basis no statistical ($T^2 = 1.13$) or apparent (table 20) difference in means resulted. This implies the mix of tanks and TOWs rather than a difference in weapons system effectiveness caused the discrepancy in Red kills.

Table 19. Means and standard deviations of Red vehicles kills for tank organizations in deliberate attack.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses to Tanks	25	7.76	1.67	10.48	2.04
Red Losses to TOWs	25	6.08	1.68	3.44	1.96

Table 20. Means and standard deviations of Red vehicle kills per weapons system for tank organizations in deliberate attack.

MOE/MOP	Observations Per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses per Tank	25	.31	.07	.33	.06
Red Losses per TOW	25	.22	.06	.19	.11

(3) Table 21 presents the average number of Red tank, BRDM, and BMP kills achieved by the Blue organizations. Since two BRDMs were destroyed in every replication, no variance existed for BRDM kills. Because this led to a singular covariance matrix, Hotellings T^2 could not be computed. To overcome this problem the matrix entries for BRDM kills were eliminated and the test was performed only on average tank and BMP kills. A nonsignificant T^2 value of .95 was obtained.

Table 21. Means and standard deviations of Red kills by type for tank organizations in deliberate attack.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	3.92	.28	3.96	.20
BRDMS	25	2.00	.00	2.00	.00
BMPs	25	7.92	.40	7.96	.35

(4) While TOW losses were roughly equivalent for the comparison organization, table 22 displays that on the average the T-series organization lost 3.08 fewer tanks than the H-series organization. Statistically, a T^2 value of 16.06 ($p < .01$) confirmed a difference in the vectors of means. As before, to assess the relative survivability of the weapons systems, the Blue tank and TOW losses per original weapons system were considered (table 23). On a per weapons system basis, it was observed that tank survivability was roughly equivalent while the T-series TOWs demonstrated better survivability. This result was supported by a computed T^2 of 7.85 ($p < .1$) and 90 percent confidence intervals of:

$$-.06 < \bar{X}_{Ttk} - \bar{X}_{Htk} < .07$$

$$-.14 < \bar{X}_{Ttow} - \bar{X}_{Htow} < -.01$$

To aid in the interpretation of greater relative survivability by the T-series TOWs, tables 24 and 25 present the MOE/MOP characterizing tank and TOW achievements in the two organizations.

Table 22.. Means and standard deviations of Blue losses for tank organizations in deliberate attack.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	11.72	2.44	14.80	3.64
TOWs	25	4.64	2.98	4.32	1.97

Table 23. Means and standard deviation of Blue losses per original weapons system for tank organization in deliberate attack.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	.47	.10	.46	.11
TOWs	25	.17	.11	.24	.11

Table 24. Means and standard deviations of the MOE/MOP for tank weapons from the tank organizations employed in the deliberate attack.

MOE/MOP	Observations Per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	.71	.26	.78	.33
Percent Red Losses Per Weapon	25	2.91	.60	3.05	.56
Weapon Engagement Rate (rds/min/wpn)	25	.25	.05	.25	.06
Effective Firepower Percentage	25	60.95	10.29	50.71	8.93
Average Engagement Range	25	2313.96	120.19	2305.40	121.53

Table 25. Means and standard deviations of the MOE/MOP for TOW weapons from the tank organizations employed in deliberate attack

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	1.94	1.96	.93	.56
Percent Red Losses per Weapon	25	1.70	.48	1.57	.94
Weapon Engagement Rate (rds/min/wpn)	25	.14	.04	.17	.07
Effective Firepower Percentage	25	55.09	9.76	51.50	13.41
Average Engagement Range	25	2262.33	311.64	1831.11	483.09

d. Mech Organizations in Deliberate Attack.

(1) Means and standard deviations of the measures of overall effectiveness, LER and TIME, are presented in table 26. As with the tank organizations in the deliberate attack, the H-series organization terminated the battle quicker but achieved a lower LER than the T-series organization. A difference in the vectors of means was confirmed by a T^2 value of 38.96 ($p < .001$). The 90 percent confidence intervals for the differences in means were computed as:

$$.04 < \overline{LER}_T - \overline{LER}_H < .24$$

$$.10 < \overline{TIME}_T - \overline{TIME}_H < 1.37$$

Table 26. Overall effectiveness means and standard deviations for mech organizations in deliberate attack.

MOE/MOP	Observations Per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
LER	25	.69	.19	.55	.12
TIME	25	18.22	.94	17.48	1.08

(2) The average Red vehicle kills attributed to Blue tanks and TOWs are shown in table 27. On the basis of a computed T^2 value of 1.64, the null hypothesis of equivalent mean vectors could not be rejected at the $\alpha = .10$ level. The same statistical conclusion was obtained on a per weapons system basis where $T^2 = 3.95$ (table 28).

Table 27. Means and standard deviations of Red vehicle kills for mech organizations in deliberate attack.

MOE/MOP	Observations Per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses to Tanks	25	4.48	1.78	3.88	1.54
Red Losses to TOWs	25	9.16	1.93	9.72	1.67

Table 28. Means and standard deviations of Red vehicle kills per weapons system for mech organization in deliberate attack.

MOE/MOP	Observations Per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses Per Tank	25	.41	.16	.39	.15
Red Losses Per TOW	25	.21	.04	.23	.04

(3) Table 29 displays that the average number of Red kills by type were nearly equivalent for the two organizations. Because this near equivalence resulted in a T^2 of only .13, the null hypothesis was not rejected.

Table 29. Means and standard deviations of Red kills by type for the mech organizations in deliberate attack.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	3.88	.33	3.84	.62
BRDMs	25	1.96	.20	1.96	.20
BMPs	25	7.80	.50	7.80	.87

(4) The average numbers of Blue tanks and TOWs destroyed are exhibited in table 30. Since a significant T^2 value of 47.77 ($p < .001$) was obtained, the null hypothesis of equivalent mean vectors was rejected. The results indicated on the average more tanks were destroyed in the T-series organization while more TOW vehicles were destroyed in the H-series organization. Table 31 displays the relative survivabilities of these same weapon systems; that is, Blue weapon systems destroyed per original weapon system. On this per weapons system basis, the null hypothesis of equivalent mean vectors was also rejected ($T^2 = 37.80$; $p < .001$). The 90 percent confidence intervals for mean differences were computed to be:

$$-.03 < \bar{X}_{Ttk} - \bar{X}_{Htk} < .20$$

$$-.20 < \bar{X}_{Ttow} - \bar{X}_{Htow} < -.06$$

These confidence intervals imply the H-series tanks were somewhat more survivable than the T-series tanks on a relative basis while the reverse was true for TOW vehicles. Tables 32 and 33 display the individual MOE/MOP of the Blue tanks and TOWs, respectively.

Table 30. Means and standard deviations of Blue losses for mech organizations in deliberate attack.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	7.88	2.13	6.32	1.70
TOWs	25	13.60	4.82	18.96	4.51

Table 31. Means and standard deviations of Blue losses per original weapons system for mech organization in deliberate attack.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	.72	.19	.63	.17
TOWs	25	.31	.11	.44	.11

Table 32. Means and standard deviations of the MOE/MOP for tank weapons from the mech organizations employed in deliberate attack.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	.66	.44	.70	.40
Percent Red Losses Per Weapon	25	4.53	1.65	4.05	1.31
Weapon Engagement Rate (rds/min/wpn)	25	.26	.09	.15	.05
Effective Firepower Percentage	25	74.22	14.95	62.00	16.07
Average Engagement Range	25	2348.14	188.10	2353.56	180.50

Table 33. Means and standard deviations of the MOE/MOP for TOW weapons from the mech organizations employed in deliberate attack.

MOE/MOP	Observations per Group	T-Series Mech		H-Series Mech	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	.74	.27	.55	.17
Percent Red Losses Per Weapon	25	1.78	.44	2.12	.33
Weapon Engagement Ratio (rds/min/wpn)	25	.11	.03	.12	.03
Effective Firepower Percentage	25	59.56	10.82	56.77	5.89
Average Engagement Range	25	1948.53	236.50	1920.58	308.04

e. Tank Organizations in Covering Force Action.

(1) Unlike the CARMONETTE replications used for the previous comparisons, the time of battle termination was controlled in the CARMONETTE runs for the last comparison. Since battle termination time was no longer free to vary, it was useless as a measure of overall performance. On the other hand, Red losses were no longer controlled and were free to vary. For this reason total Red losses were substituted for battle termination times in the analysis methodology. In addition, because LER considers both Blue and Red losses and Red losses were already being considered, Blue losses were substituted for LERs in the analysis. Thus, total Red and Blue losses served as the indicants of overall effectiveness in the final comparison. Table 34 shows that the T-series organization outperformed the H-series organization by achieving more Red kills and suffering fewer losses on the average. This statement was confirmed by a significant difference in the mean vectors (T^2 = 52.84; $p < .001$) and the following confidence intervals:

$$8.46 < \overline{RL}_T - \overline{RL}_H < 15.94$$

$$-5.39 < \overline{BL}_T - \overline{BL}_H < -.77$$

Table 34. Overall effectiveness means and standard deviations for tank organizations in covering force action

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Blue Losses	25	12.84	3.82	15.92	3.52
Red Losses	25	55.68	5.60	43.48	6.28

(2) Table 35 depicts the ability of the tanks and TOWs from the two organizations to kill Red vehicles. The computed test statistic value, 90.76 ($p < .001$), denoted a difference in the vectors of means. The disparity in Red kills by TOW vehicles stands out as the major difference. On a per weapons system basis this disparity disappeared (table 36); however, an apparent difference developed for Red losses per tank. A difference in the mean vectors on a per weapons system basis was indicated by a T^2 value of 12.93 ($p < .01$). Subsequent computation of the 90 percent confidence intervals yielded:

$$.05 < \bar{X}_{Ttk} - \bar{X}_{Htk} < .24$$

$$-.06 < \bar{X}_{Ttow} - \bar{X}_{Htow} < .15$$

The exclusion of zero from the confidence interval computed for tank differences and its range infers a better performance by the T-series tank. Table 37 presents the MOE/MOP measures characterizing tank performance in the alternative organizations.

Table 35.. Means and standard deviations of Red vehicle kills for tank organizations in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses to Tanks	25	21.08	4.19	22.44	4.14
Red Losses to TOWs	25	24.68	3.76	15.04	3.39

Table 36. Means and standard deviations of Red vehicle kills per weapons system for tank organization in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Red Losses per tank	25	.84	.17	.70	.13
Red Losses per TOW	25	.88	.13	.84	.19

Table 37. Means and standard deviations of the MOE/MOP for tank weapons from the tank organizations employed in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	5.17	3.34	3.25	1.57
Percent Red Losses per Weapon	25	1.69	.27	1.86	.33
Weapon Engagement Rate (rds/ min/wpn)	25	.25	.03	.25	.02
Effective Firepower Percentage	25	96.38	3.71	98.71	2.03
Average Engagement Range	25	2382.82	52.77	2429.94	42.51

(3) The average number of Red tank, BRDM, and BMP kills is presented in table 38. A T^2 value of 46.02 ($p < .001$) indicated a difference in the vectors of means. It appeared the greater number of total Red kills by the T-series organization transformed into a greater number of individual tank, BRDM, and BMP kills by the T-series organization. The 90 percent confidence intervals for average differences were calculated to be:

$$1.82 < \bar{X}_{Ttk} - \bar{X}_{Htk} < 4.34$$

$$0.00 < \bar{X}_{Tbrdm} - \bar{X}_{Hbrdm} < 2.32$$

$$1.27 < \bar{X}_{Tbmp} - \bar{X}_{Hbmp} < 6.81$$

Table 38. Means and standard deviations of Red kills by type for the tank organizations in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	15.96	1.54	12.88	1.83
BRDMS	25	6.96	1.62	5.80	1.50
BMPS	25	22.84	3.26	18.80	4.12

(4) The average number of Blue tank and TOW vehicle losses are exhibited in table 39. A significant T^2 value of 19.81 ($p < .001$) conveyed that a difference in the vectors of means existed between the comparison organizations. From the table, it is obvious the significant result was obtained because the T-series organization lost fewer tanks than the H-series organization. On a per weapon system basis this trend is somewhat less apparent in table 40. But, in this same table, TOW vehicles from the T-series organization demonstrate far greater relative survivability than TOW vehicles from the comparison organization. This

Table 39. Means and standard deviations of Blue losses for tank organizations in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	5.12	2.03	7.84	2.61
TOWs	25	7.60	2.33	7.72	1.49

Table 40. Means and standard deviations of Blue losses per original weapons system for tank organizations in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Tanks	25	.20	.08	.25	.08
TOWs	25	.27	.08	.43	.08

result was affirmed by a significant test statistic ($T^2 = 46.99$; $p < .001$) and the following 90 percent confidence intervals for the mean differences:

$$-.09 < \bar{X}_{Ttk} - \bar{X}_{Htk} < .01$$

$$-.21 < \bar{X}_{Ttow} - \bar{X}_{Htow} < -.11$$

The MOE/MOP characterizing tank performance were previously presented in table 37 and the corresponding MOE/MOP for TOWs are displayed in table 41.

Table 41. Means and standard deviations of the MOE/MOP for TOW weapons from the tank organizations employed in covering force action.

MOE/MOP	Observations per Group	T-Series Tank		H-Series Tank	
		Mean	Standard Deviation	Mean	Standard Deviation
Weapon Loss Exchange Ratio	25	3.50	1.07	2.06	.77
Percent Red Losses per Weapon	25	1.84	.28	2.44	.42
Weapon Engagement Rate (rds/min/wpn)	25	.11	.01	.11	.02
Effective Firepower Percentage	25	91.82	5.57	84.75	3.17
Average Engagement Range	25	2631.47	48.36	2639.23	63.42

13. INTERPRETATION OF RESULTS.

a. General. The previous paragraph presented the CARMONETTE gaming results and their statistical analysis, which established many significant statistical differences between the T-series and H-series organizations. At issue, however, is not whether the organizations are different in a statistical sense, but whether they are different in a practical sense. The following subparagraphs further discuss and investigate the gaming results to ascertain if any of the observed statistical differences also have a practical significance tactically.

b. Position Defense Comparisons. The position defense was conducted in a target rich environment. The scenario was designed to test each organization's ability to service targets adequately. Since the Blue force was positioned with the bulk of its force on-line and conducted little movement, this scenario provides a relative evaluation of the amount of firepower each organization was able to generate against an initially equal threat force.

(1) H-series versus T-series tank organizations.

(a) Overall combat effectiveness. The differences in the MOE for overall combat effectiveness of the alternative tank organizations were found to be multivariate statistically significant. This significance was based on force loss exchange ratio and time. Figure 5 is a time plot of the LERs achieved by both tank organizations. The plot shows that, except for the initial engagements, the H-series tank organization was able to maintain a higher LER throughout the battle than the T-series tank organization. Figures 6 and 7 are time plots of the corresponding Red losses to and Blue losses suffered by the tank organizations. As can be seen in figure 6 both organizations attained about the same number of Red kills. The H-series organization, however, attained the kills sooner and, thus, effectively serviced the Red targets at a higher rate than the T-tank organization. Figure 7 shows that the H-tank organization was able to sustain an average of 7.56 fewer armored vehicle losses than the T-tank. Figure 8 depicts the SMFRD attained by each tank organization. This plot indicates that both organizations won the battle. Since both tank organizations destroyed the same percent of the Red force, the SMFRD plots show that the H-tank had 10 percent more of its force remaining at the end of the battle than did the T-series tank organization.

(b) Weapon system performance. Since the position defense scenario stressed the Blue force ability to service targets, the prime measure of performance in determining the contributions of the major direct fire weapon systems to the effectiveness of their organizations was considered to be the percent of Red losses killed by each type of weapon system.

1. An analysis of both tank organizations showed that the H-series XM-1s were responsible for an average of 64 percent of the total Red losses and the TOW vehicles were responsible for an average of 34 percent. Figure 9 is a plot of the percent of the cumulative Red losses over time that are attributable to Blue H-series XM-1s and TOW vehicles. Figure 9 clearly shows that the XM-1s were the principal contributor to the Red losses. The H-series XM1s were responsible for almost two-thirds of the Red losses. The T-series TOW vehicles, on the other hand, killed more of the Red force than the T-series XM1s. The T-series tank organization killed 45 percent of the Red losses with its XM1s and 51 percent with its TOW vehicles. Figure 10 is a time plot of the percent of the cumulative Red losses attributable to each of the T-series direct fire weapon systems. This plot indicates that initially the T-series TOW vehicles were responsible for about twice as many Red losses as the XM1s. However, primarily due to the attrition/suppression of the TOW vehicles as the battle progressed, the TOWs were killing only slightly more of the Red force than the XM1s at the end of the battle. Considering these relationships, the key to the H-series tank organization's greater success appears to be the ability of the H-series XM1s to better service the Red targets than the T-series XM1s. Figure 11 is a time plot of the cumulative Red losses killed by the XM1s of each organization. This plot shows that the H-series XM1s killed 20 percent to 30 percent more of the Red force than the T-series XM1s.

2. It was shown in the statistical analysis that the T-series XM1s achieved higher engagement rates than the H-series XM1s. In table 5 the average weapon engagement rate for T-series XM1s was 1.34 (rounds/minute/tank), while the H-series XM1 average engagement rate was 1.24 (rounds/minute/tank). A plot of the average engagement rates for the XM1s of both tank organizations during each minute of combat is depicted in figure 12. This figure shows that the H-series XM1s initially fired faster, but in the mid and latter stages of the battle the T-series XM1s had the higher engagement rates. To understand these performance parameters better, it is helpful to translate to the total number of rounds fired each minute by all the XM1s in the organization. An estimate for the average number of rounds fired per minute by all XM1s from each organization may be determined through the following equation:

$$R_{ik} = N_{ik} \cdot WER_{ik} \cdot \left(1 - \frac{WLR_{ik}}{2}\right)$$

where for the kth type organization:

R_{ik} = the average number of rounds fired per minute.

N_{ik} = the number of weapon systems initially in the organization.

WER_{ik} = the average weapon engagement rate.

WLR_{ik} = the weapon loss ratio.

$\frac{1-WLR_{ik}}{2}$ = an estimate of the average fraction of weapons that survive the battle.

Application of this equation reveals that all the T-series XM1s collectively fired an average of 25.5 rounds/minute and the H-series XM1s fired an average of 30.3 rounds/minute. So, even though the T-series XM1s had higher average engagement rates, the H-series XM1s, because there were more of them, were able to fire an average of 4.8 more rounds/per minute.

3. The weapon loss exchange ratios were found in the statistical analysis (as shown in table 5) to be 4.7:1 for the H-series XM1s and 3.8:1 for the T-series XM1s. Time plots of the XM1 LERs for each tank organization are presented in figure 13. It is evident from this plot that the H-series XM1s were more effective than the T-series XM1s. However, since H-series XM1s fired only slightly more rounds per minute than the T-series, and since the effective firepower percentages and weapon loss ratios for the XM1s of both organizations are virtually the same (shown in figures 14 and 15 respectively), the difference in LERs indicates that the H-series XM1s were more effective with their shots than the T-series XM1. Considering that the XM1 accuracy and lethality data bases in CARMONETTE were identical, the increased effectiveness of the H-series XM1s must be attributed to the differences in their deployment doctrine. The differences are reflected in the average engagement ranges. The average engagement ranges for each organization's XM1s are shown in figure 16. It is apparent from this plot that the H-series XM1s consistently engaged their targets at shorter ragnes than did the T-series XM1s.

(c) Summary. The H-series tank organization displayed more combat effectiveness in both a statistical sense and a practical sense in the position defense scenario. The key to the H-series tank organization's greater success was the ability of H-series XM1s to better service the Red targets. The ability to task organize for combat allowed the H-series tank organization to deploy its XM1s in positions where they were closer to the main attack. Thus, they were able to attain a greater LER and kill a larger percentage of the Red force than the T-series XM1s.

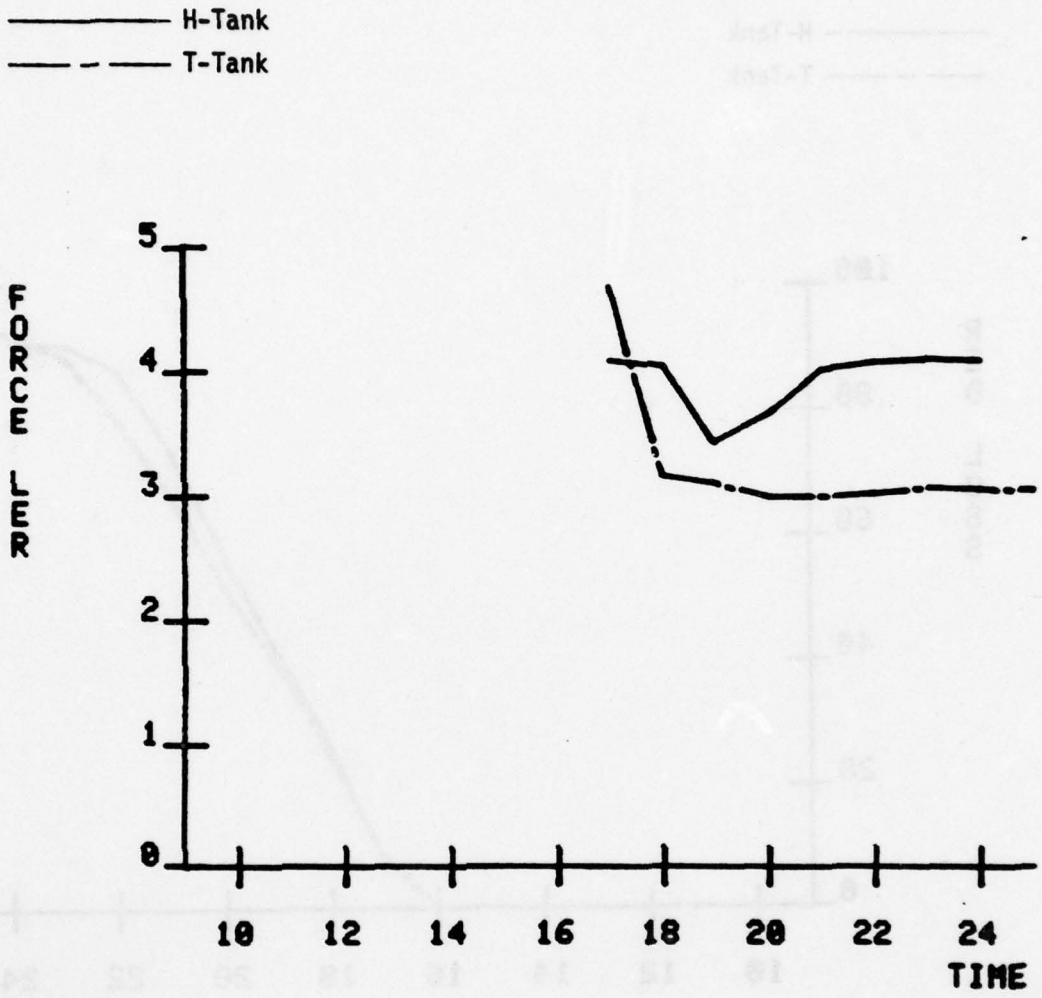


Figure 5. Loss exchange ratios achieved by tank organizations in position defense.

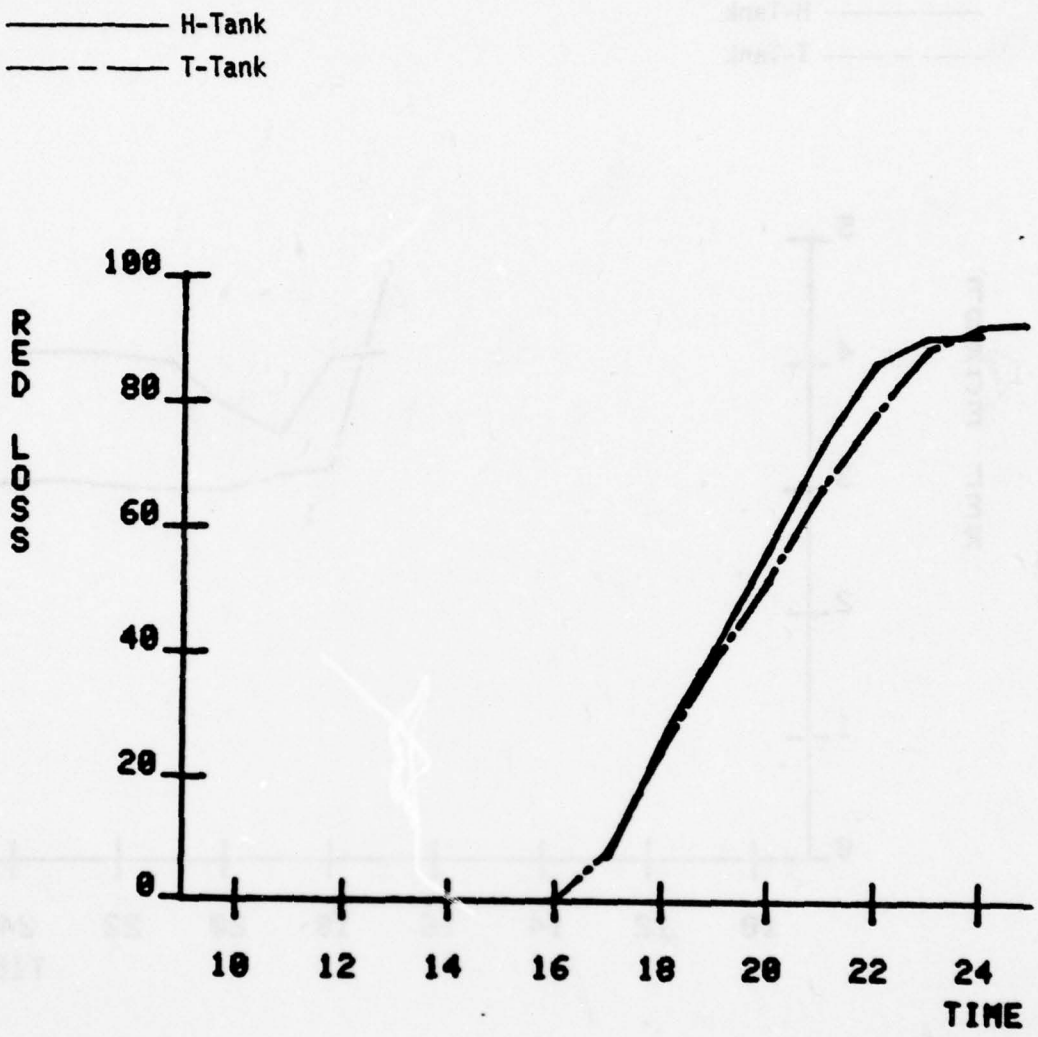


Figure 6. Red losses to tank organizations in position defense.

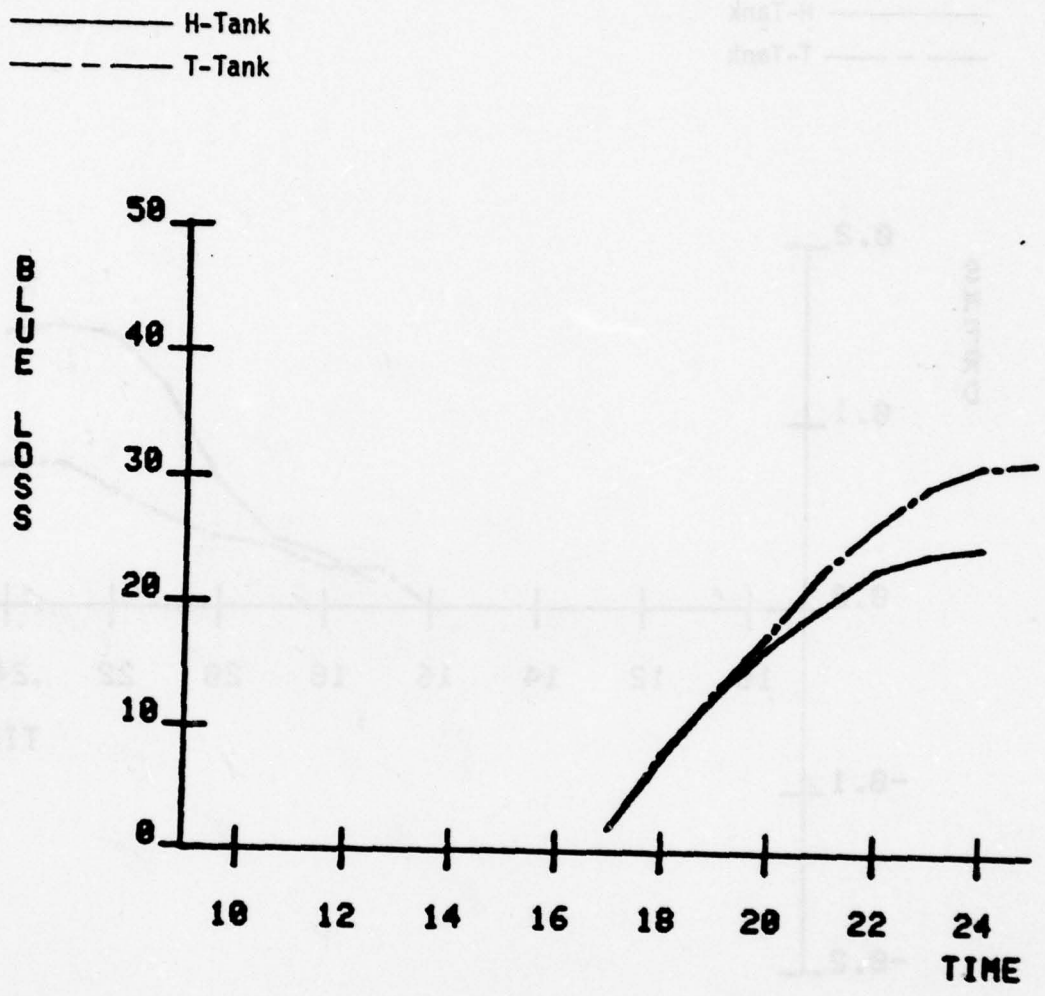


Figure 7. Blue losses suffered by tank organizations in position defense.

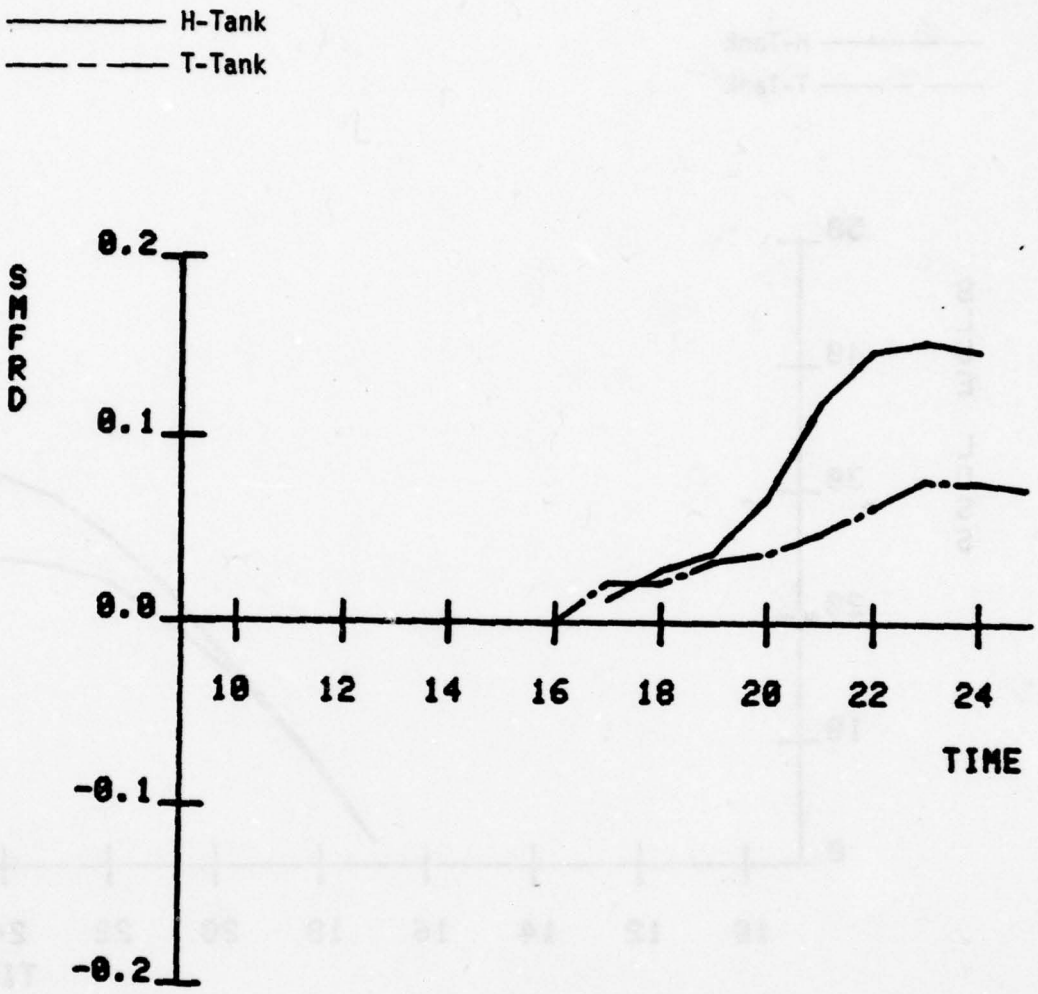


Figure 8. Surviving maneuver force ratio differentials for tank organizations in position defense.

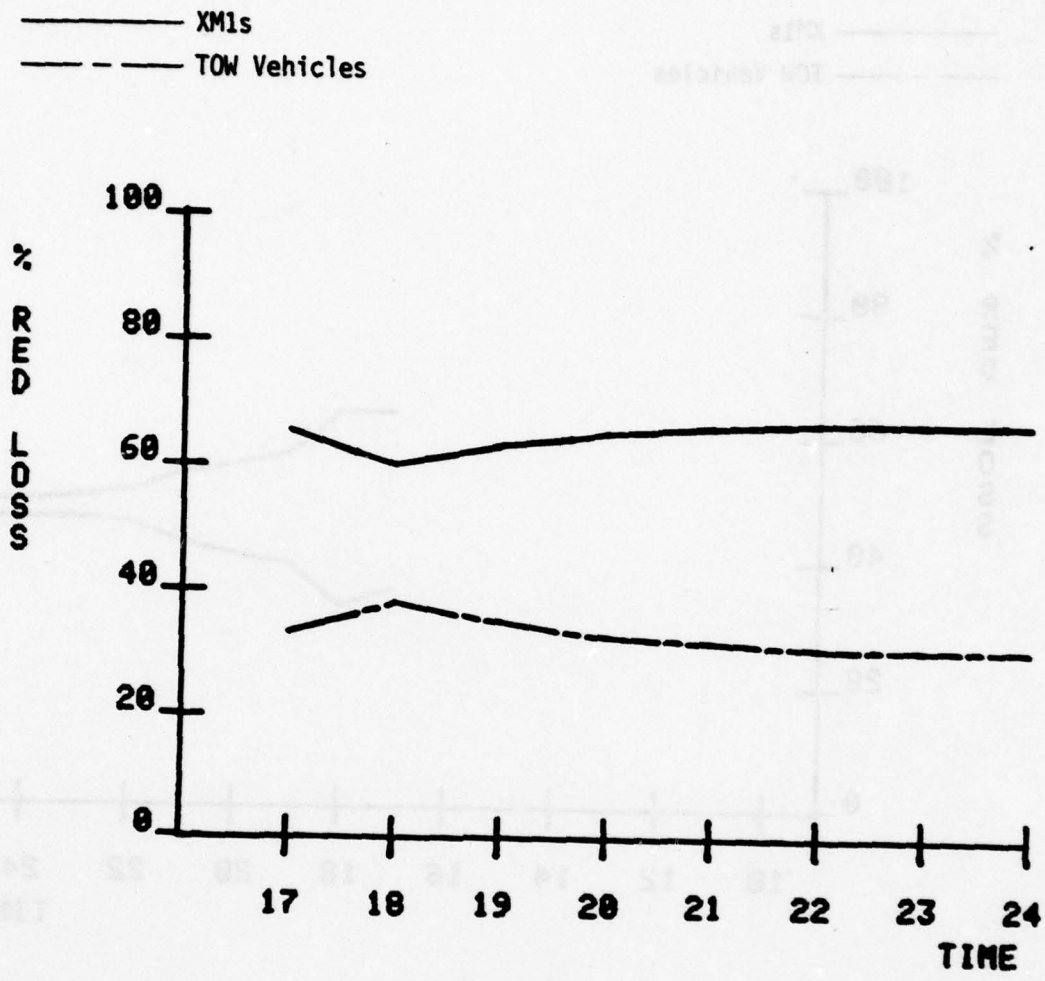


Figure 9. Percent of Red losses by H-tank organization direct fire weapon systems.

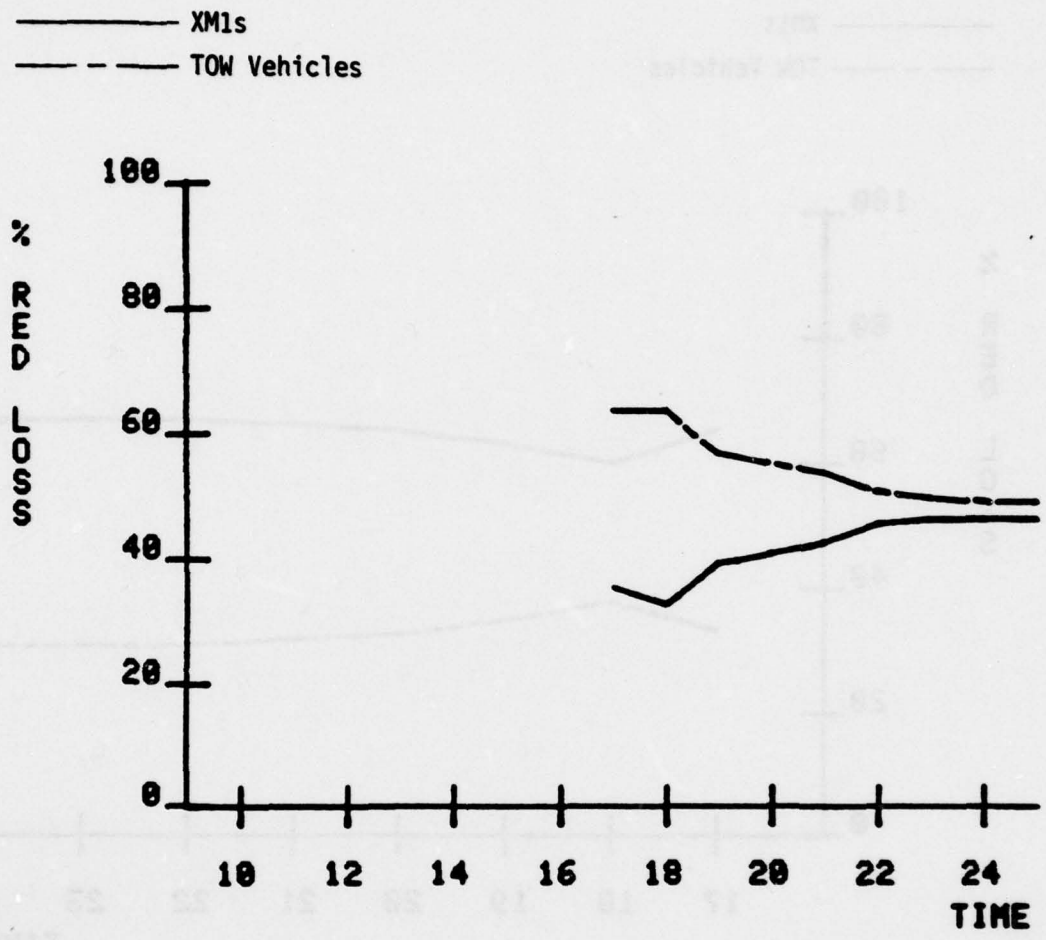


Figure 10. Percent of Red losses by T-tank organization direct fire weapon systems.

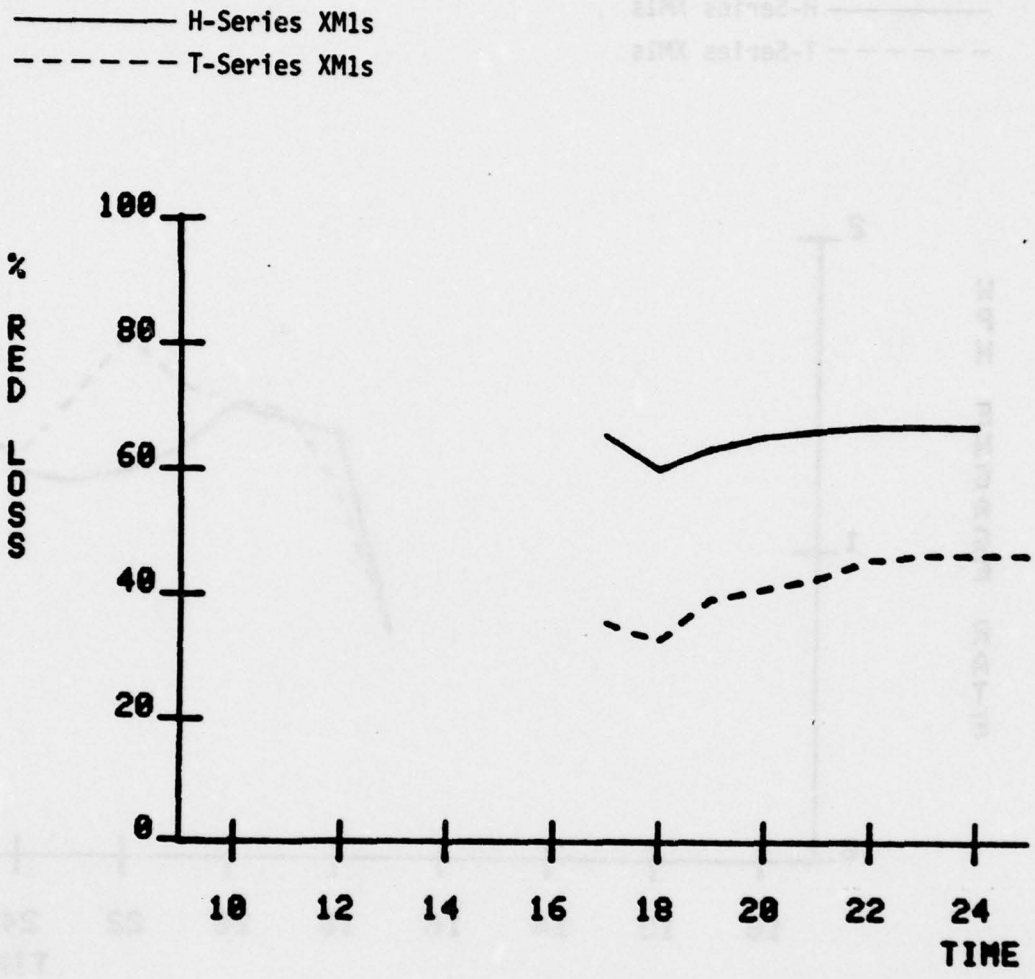


Figure 11. Percent of Red losses by H and T-series tank organization XM1s in position defense.

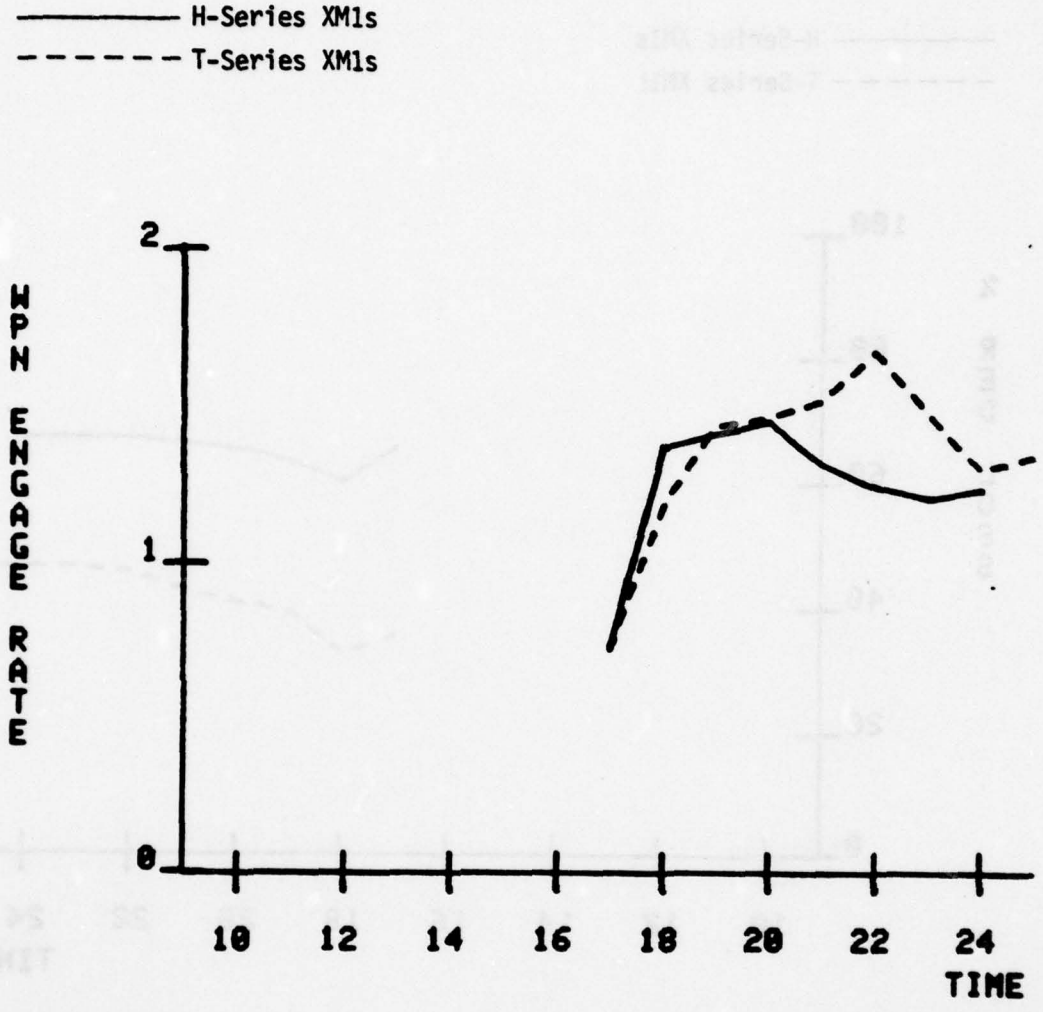


Figure 12. Average engagement rates for XM1s in position defense.

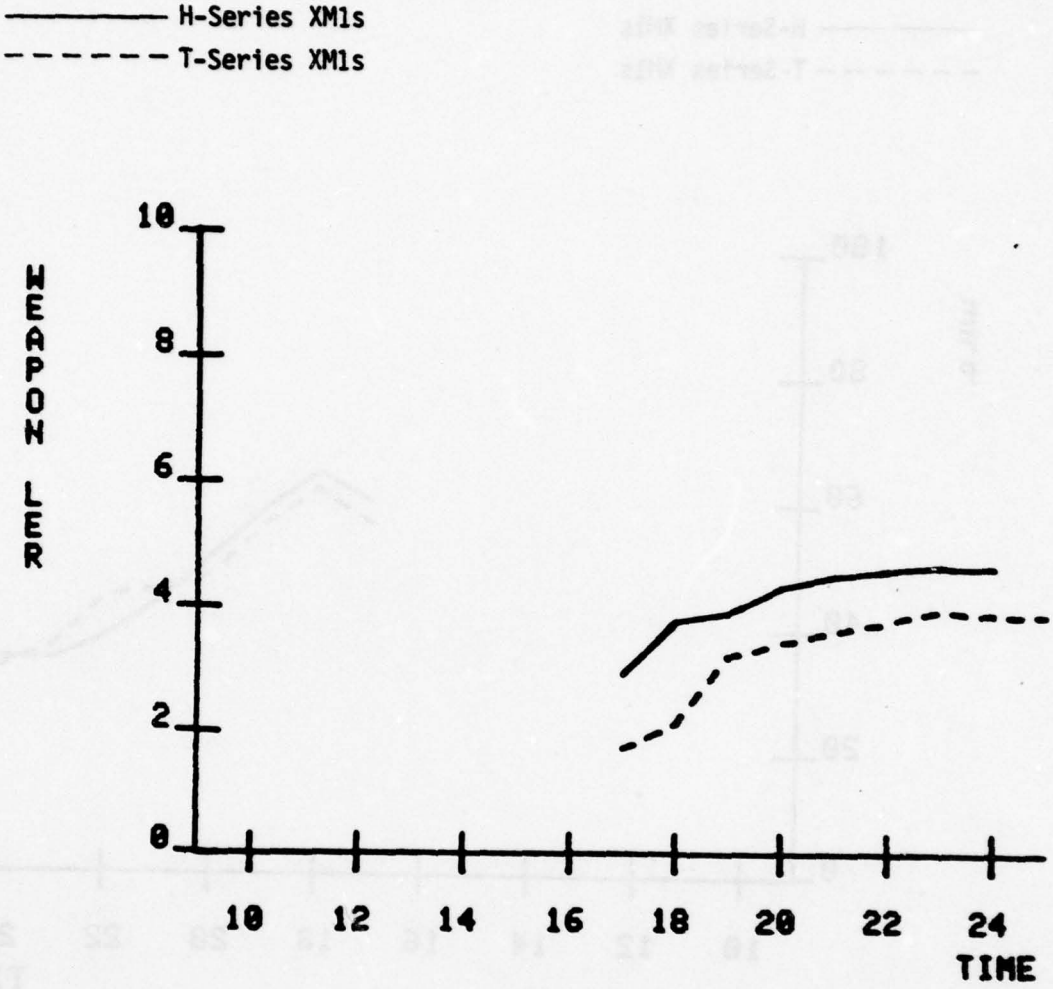


Figure 13. Loss exchange ratios for tank organization XM1s in position defense.

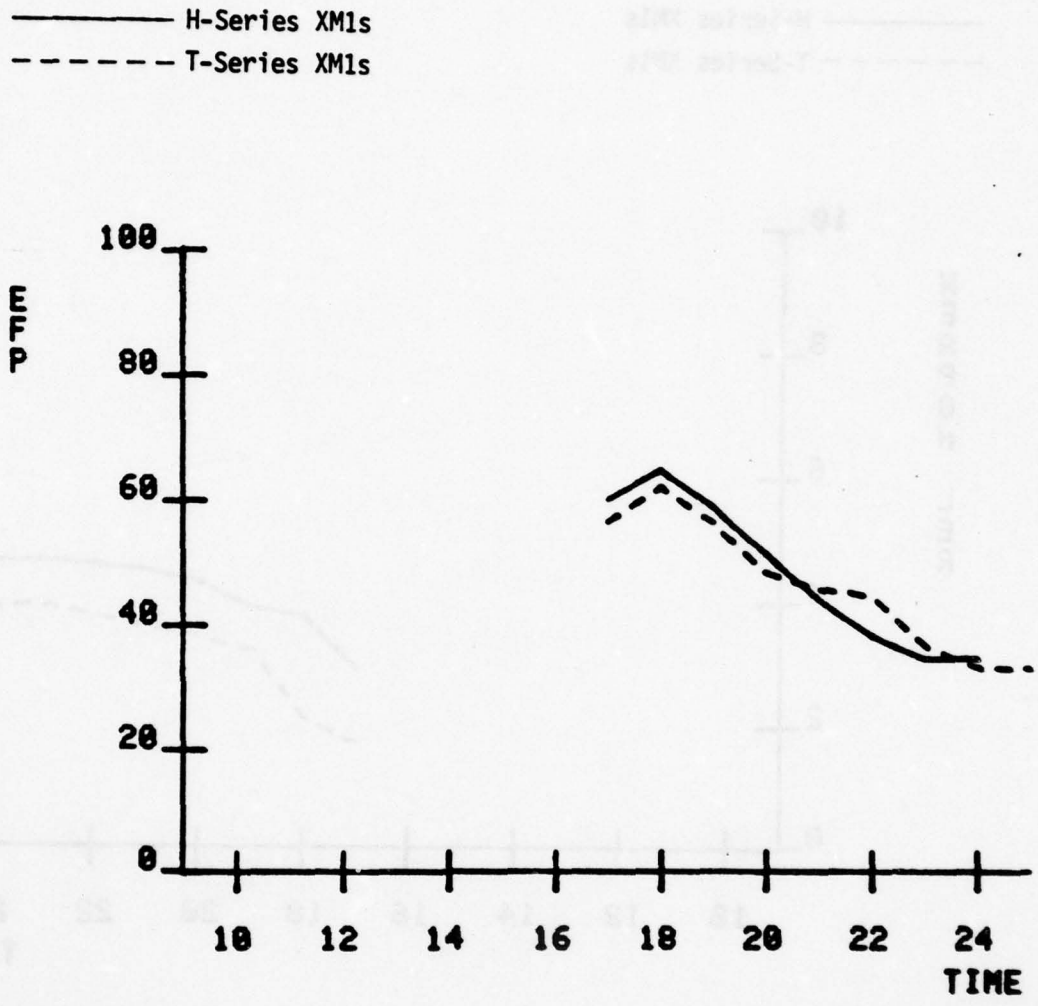


Figure 14. Effective firepower percentage for tank organization XM1s in position defense.

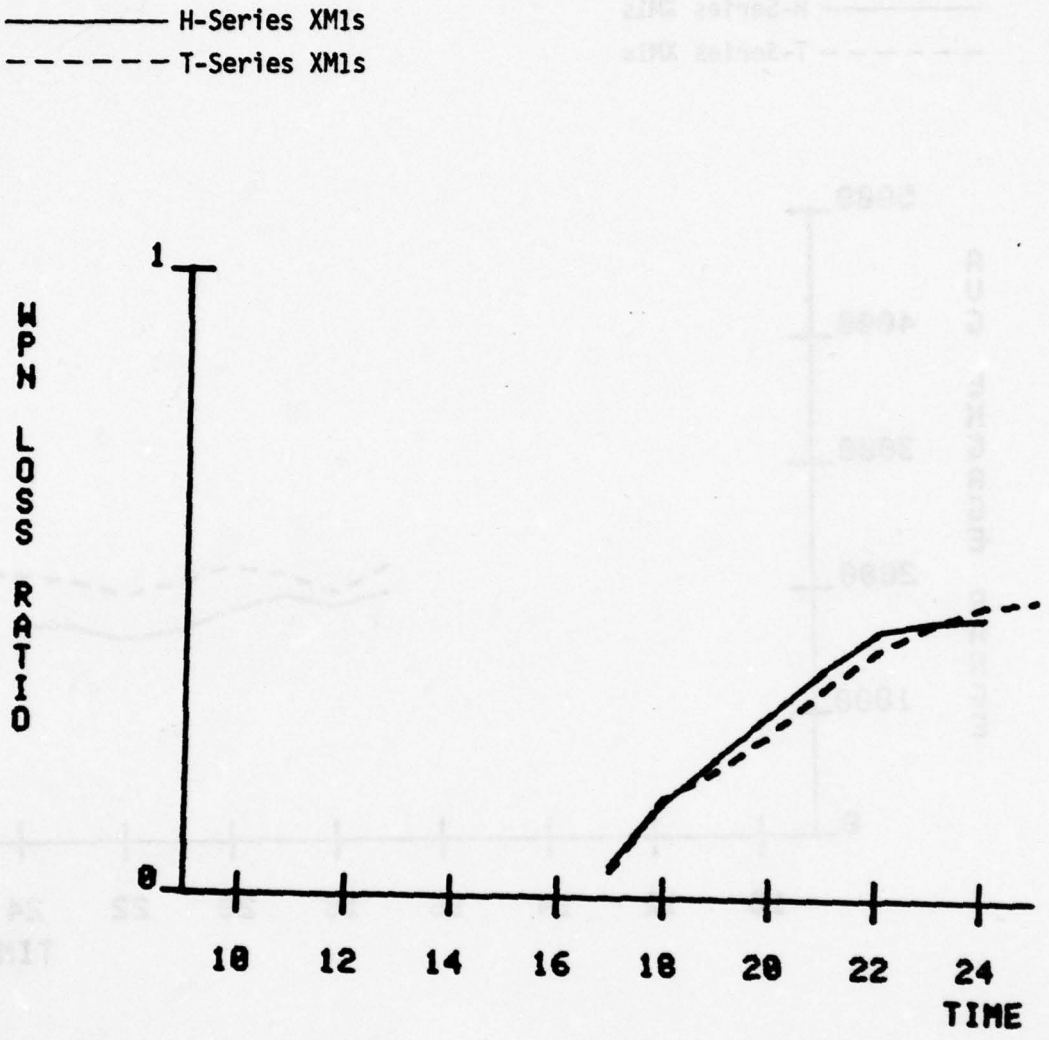


Figure 15. Weapon loss ratio for tank organization XM1s in position defense.

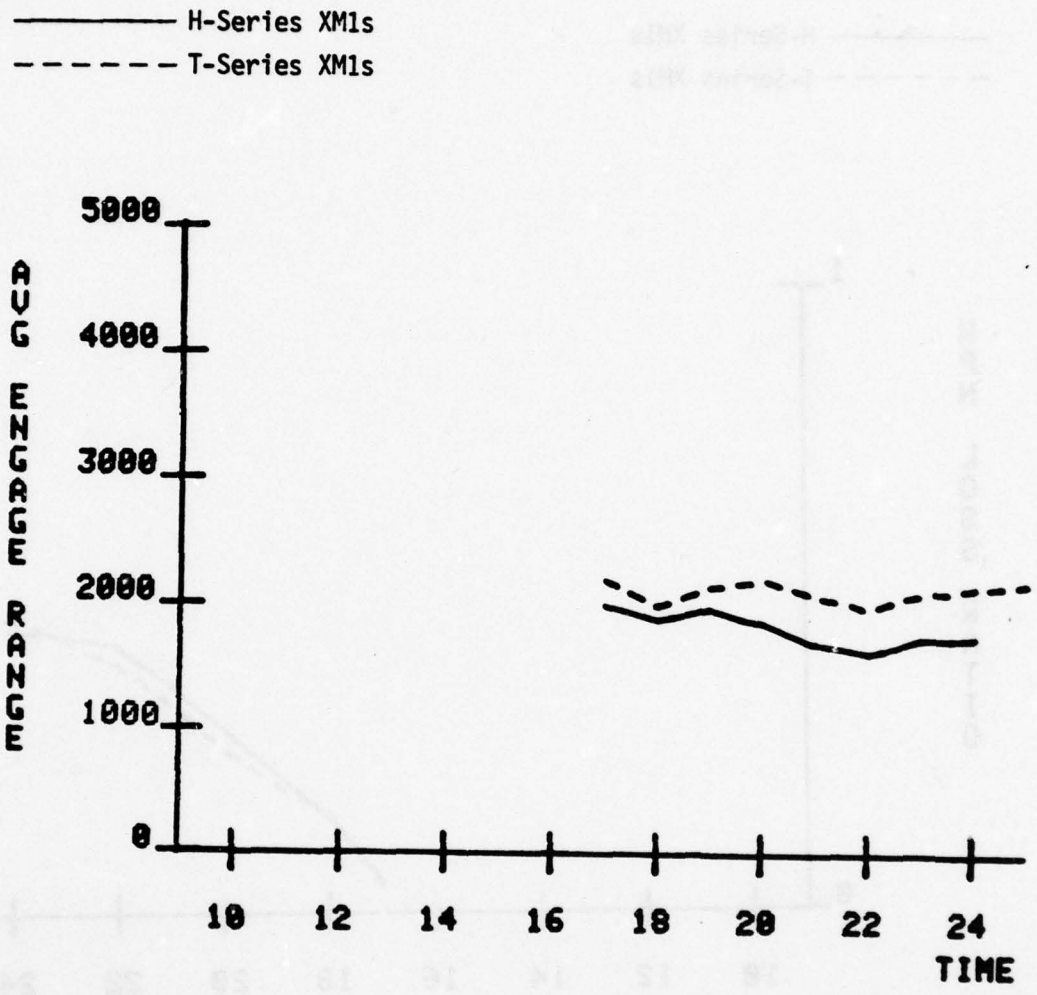


Figure 16. Average engagement ranges by tank organization XM1s in position defense.

(2) H-series versus T-series mech organizations.

(a) Overall combat effectiveness. The statistical analysis found the differences with respect to force LER and time in the overall combat effectiveness of the mech organizations to be multivariate significant. Figure 17 is the time plots of force LER for both mech organizations. The plot graphically illustrates the greater combat effectiveness displayed by the T-series mech organization. Throughout the entire battle the T-series organization was able to maintain a higher LER than the H-series organization. Plots of the Red losses and Blue losses incurred as functions of time in these scenarios are presented in figures 18 and 19, respectively. Figure 18 show that the T-series organization was able both to kill more of the Red force and to service effectively the Red targets at a higher rate than the H-series mech organization. As a result, the Blue armored vehicles losses suffered by the T-series organization were an average of 5.12 fewer than the H-series mech losses. This relationship is depicted in figure 19. The SMFRD plots for each organization are presented in figure 20. The SMFRDs show the T-series mech organization winning its battle and the H-series mech organization losing its battle.

(b) Weapon system performance. The position defense scenarios were target rich and tested the ability of both mech organizations to service targets effectively. As depicted in figure 18 the T-series organization was able to effectively service (kill) an average of 9.48 more Red armored vehicles than the H-series organization. Inspection of time plots of the percent of Red losses attributable to XM1s (figure 21) and TOW vehicles (figure 22) shows that each type of weapon system killed about the same percentage of the Red losses in its respective organization. The H-series organization, as was shown in table 15 of the statistical analysis, was more vulnerable than the T-mech organization. The H-mech lost 78 percent of its XM1s and 60 percent of its TOW vehicles; T-mech lost 52 percent of its XM1s and 53 percent of its TOW vehicles. The XM1 and TOW vehicle weapon loss ratios are plotted as functions of time in figures 23 and 24, respectively. As can be seen from these plots, the losses suffered by the TOW vehicles in each organization occurred similarly. The H-series XM1s, however, incurred a significantly higher percentage of losses than the T-series XM1s. Since the effectiveness of the TOW vehicles of each mech organization was approximately the same, the measured difference in combat effectiveness must be attributable to differences in the performance of the XM1s of each organization. Since both mech organizations contain only slightly different mixes of the same weapon systems and were being attacked by identical threats, their difference in survivability may be attributed to differences in the deployment of the organizations, in their ability to get their weapon systems into the battle, or in the performance characteristics of their weapon systems.

AD-A062 666 ARMY COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY FORT--ETC F/G 15/7
CARMONETTE BATTALION LEVEL GAMING CONDUCTED FOR DIVISION RESTRU--ETC(U)
AUG 78 T J BAILEY, M R ANDERSON, R W SNARE

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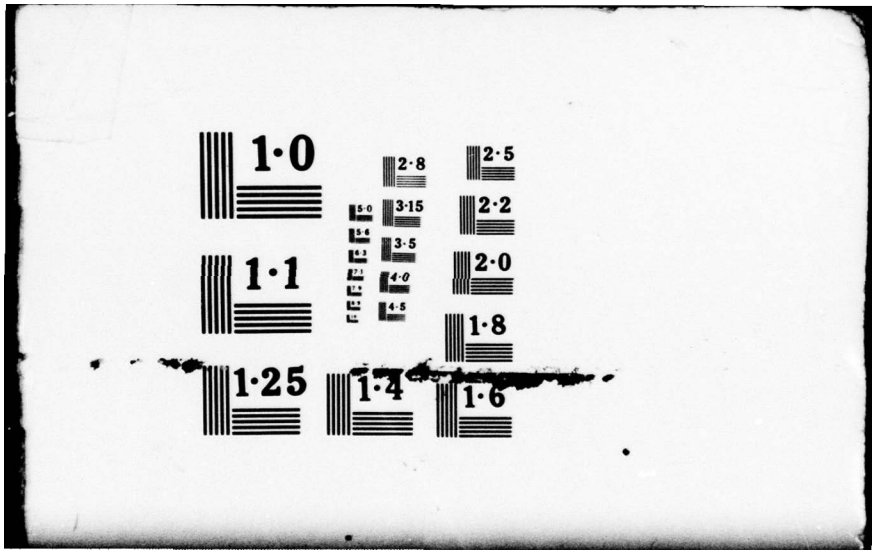
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1. The average engagement ranges for the XM1s in T-series mech organizations as shown in figure 25 were slightly longer than the H-mech engagement ranges, but for all intents and purposes they were the same. Thus, based on range only, there was little difference between the deployment of the XM1s in the two organizations. There was a difference, however, due to the organizational grouping of the weapon systems. The H-series weapons were grouped into two mech heavy company teams and positioned to cover the two expected avenues of approach. The two company teams thus positioned were located about 3km apart and could provide only a minimal amount of mutual support. The T-series weapons, on the other hand, were grouped into three pure companies. One T-series mech company covered each of the two expected avenues of approach, and a tank company was positioned between the two to provide support. Because of this deployment configuration, the T-series mech organization was able to bring to bear an amount of firepower sufficient to defeat the enemy; the H-series mech was not.

2. The effective firepower percentage (EFP), a measure of the percentage of weapon systems that fired in a battle, calculated in the statistical analysis (table 16) indicates that almost all the XM1s of both organizations got involved in the battle. The T-series EFP of 97 percent for XM1s was only slightly higher than the H-series XM1 EFP of 95 percent. Figure 26, however, indicates that at any given time during combat the T-mech had a higher percentage of its XM1s in the battle, which reflects the ability of the tank company to service both avenues of approach.

3. A comparison of the other XM1 performance parameters (table 16) shows the T-series mech XM1s average engagement rates were slightly higher than the H-series XM1. This is graphically depicted in figure 27. Accounting for the differences in weapons mix by to average number of rounds fired per minute (as in subparagraph (2) above), the T-series mech XM1s fired 13.3 rounds/minute, more than twice the 6.4 rounds/minute fired by the H-series XM1s. Accordingly, the T-mech XM1 higher fire rate coupled with their lower weapon loss ratios provided the T-series XM1s with significantly higher LERs as shown in figure 28.

(c) Summary. There is a threshold of firepower that must be brought to bear to defeat an enemy force. The H-mech organization, deployed and configured by doctrine, was able to block the main attack using slightly over half of its weapons with minimal support from the remaining weapons. This amount of firepower was apparently below the winning threshold. The T-series mech organization was able to bring about two-thirds of its weapons to bear on the Red force, including all its high rate of fire weapons (XM1s). This amount evidently was sufficiently above the firepower threshold to defeat their enemy.

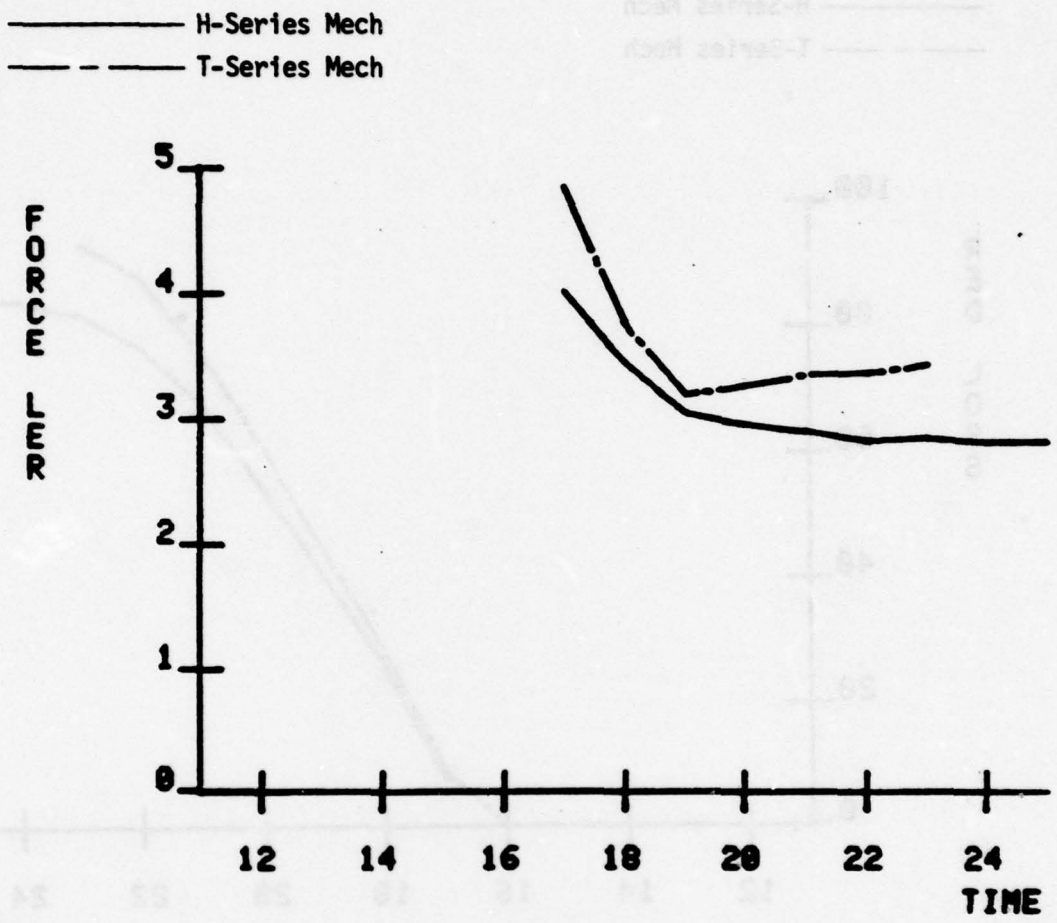

Figure 17. Force LERs for mech organizations in position defense.

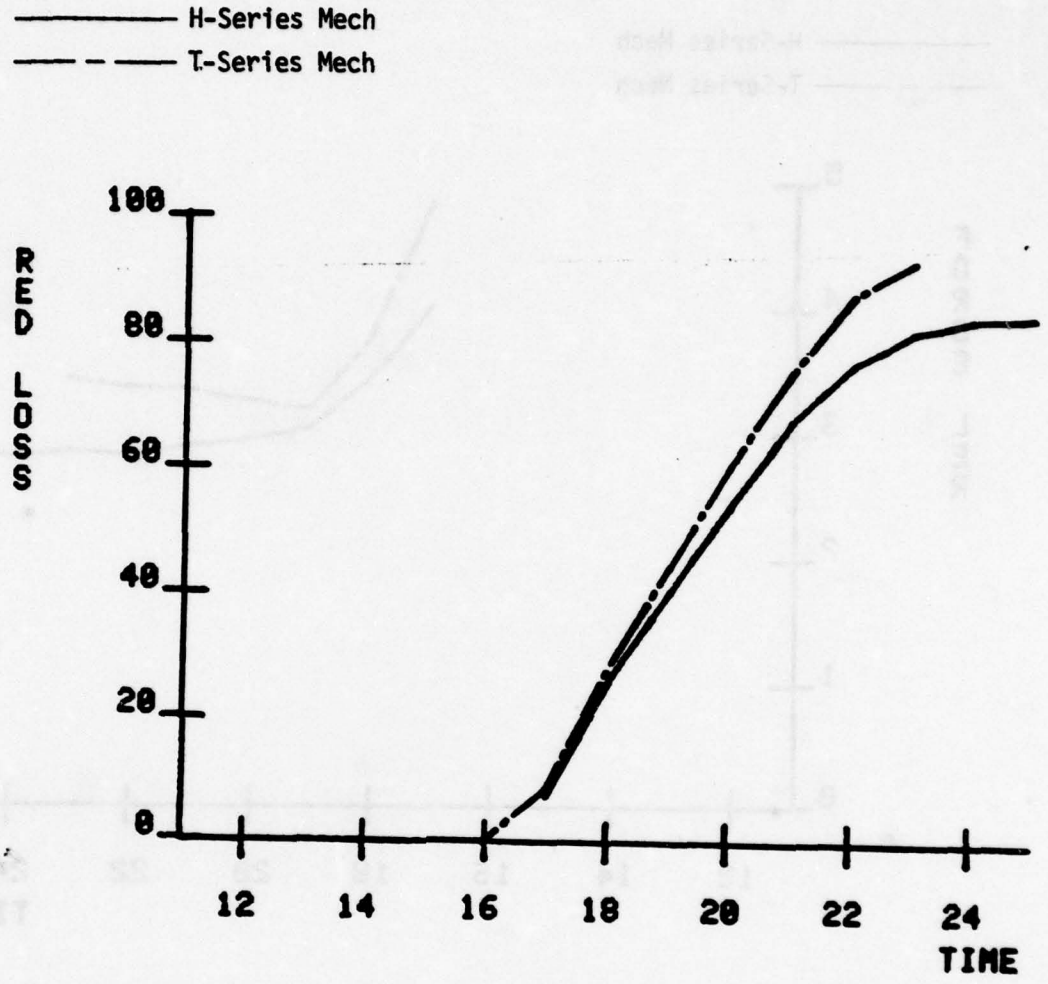

Figure 18. Red losses to mech organizations in position defense.

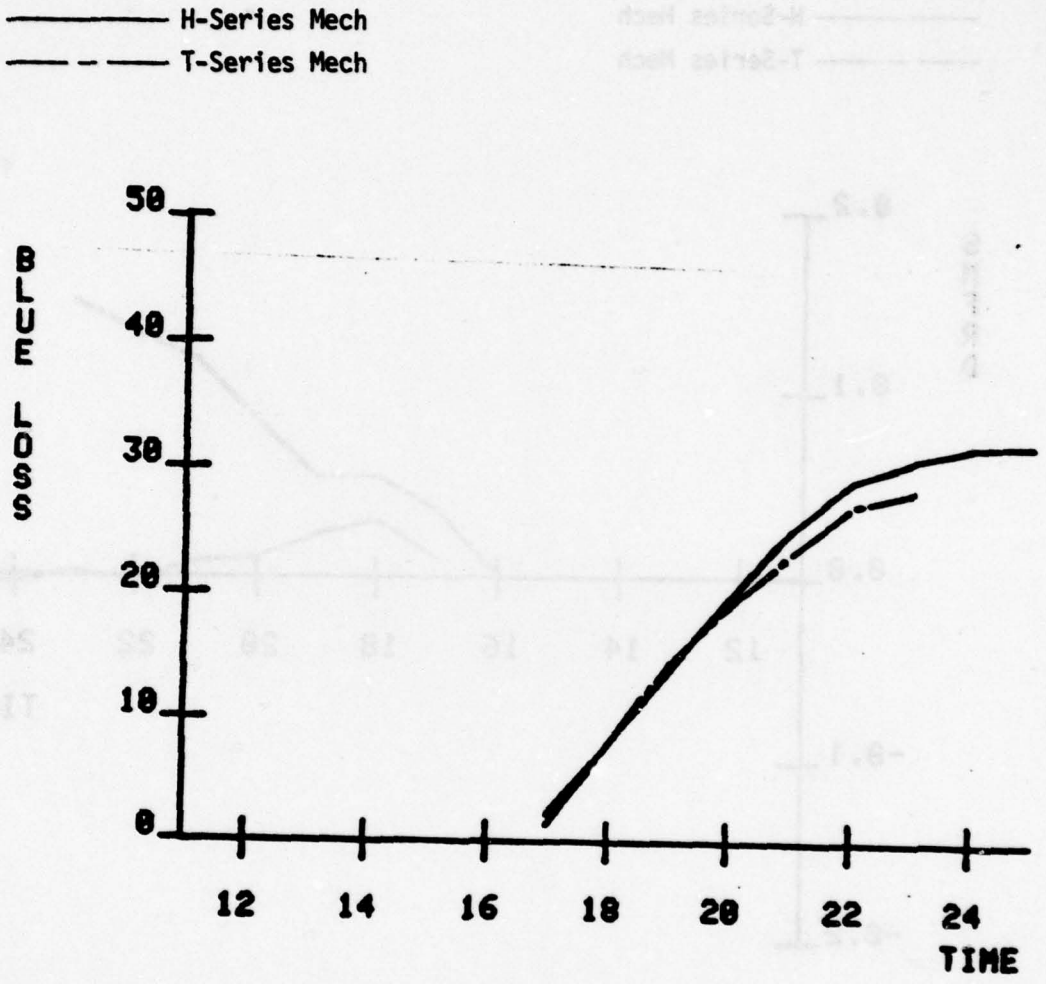

Figure 19. Blue losses incurred by mech organizations in position defense.

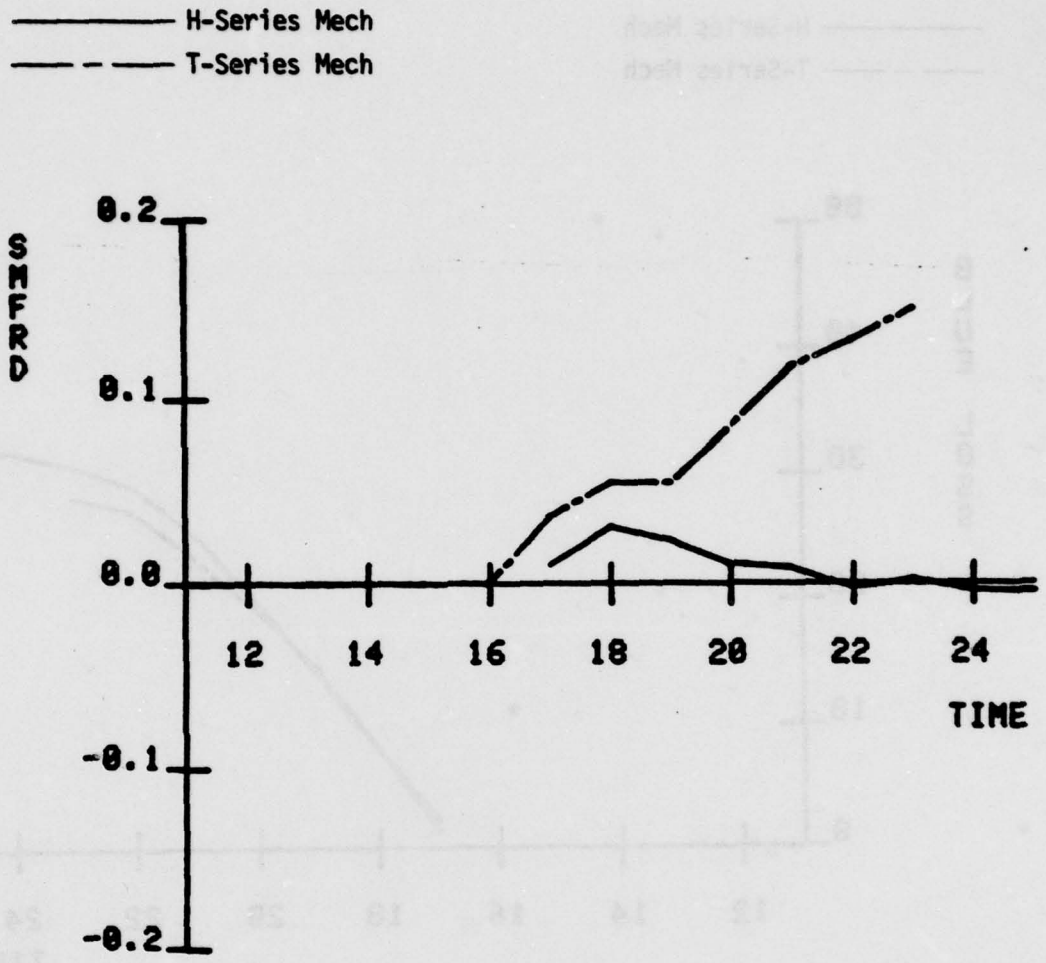

Figure 20. Surviving maneuver force ratio differential for mech organizations in position defense.

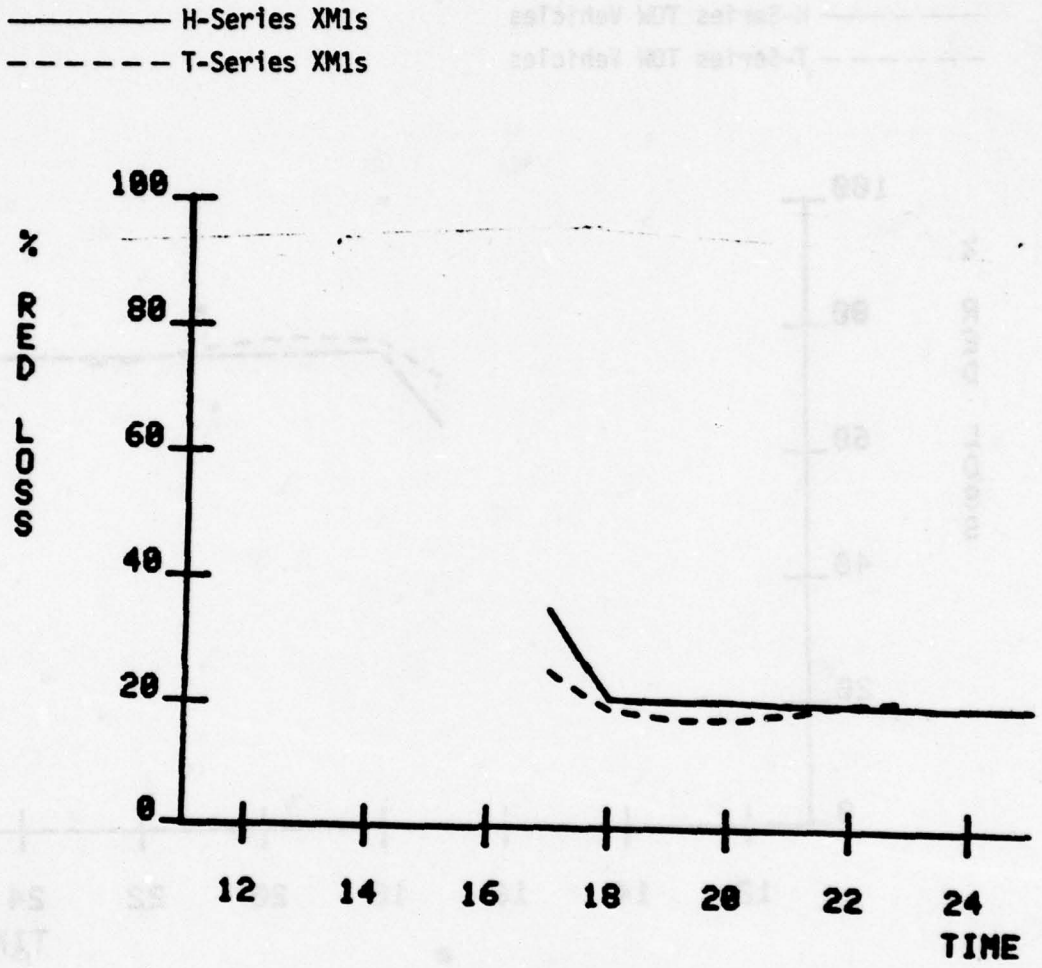

Figure 21. Percent of Red losses to mech organizations XM1s in position defense.

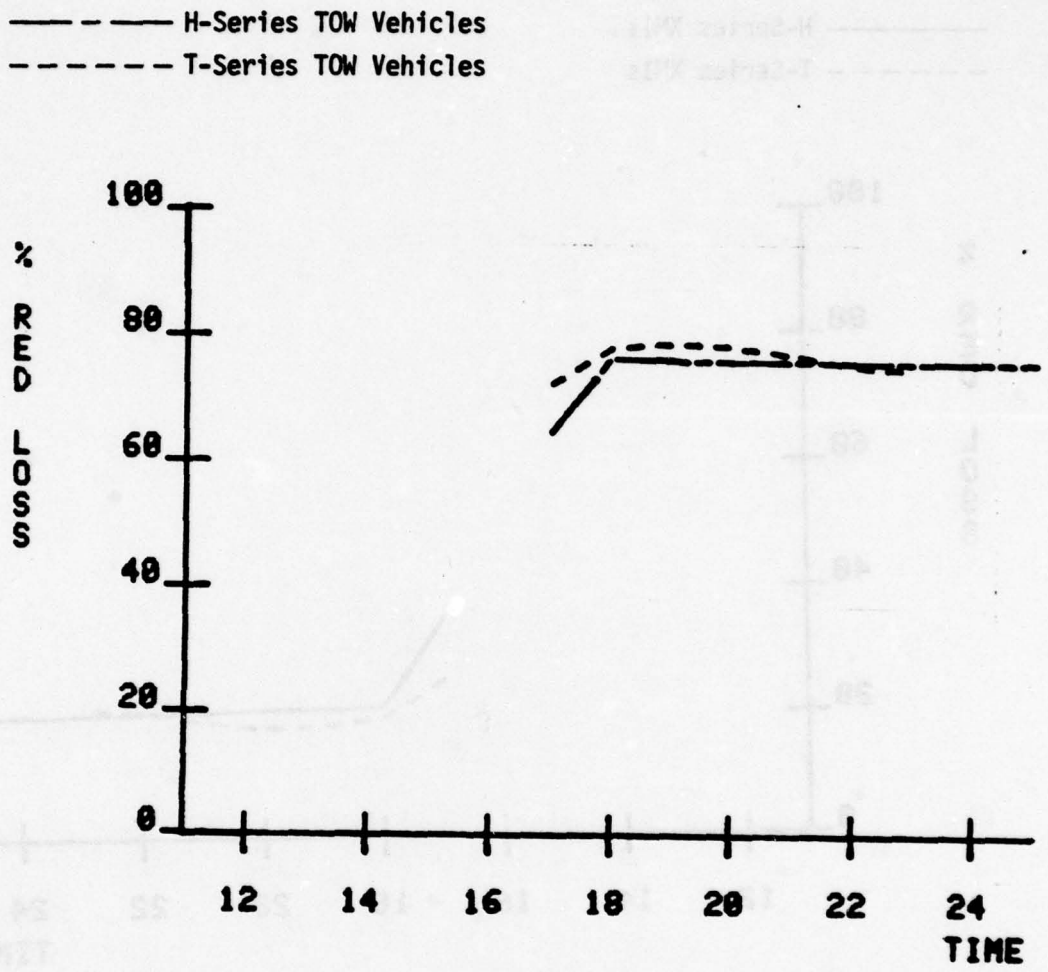

Figure 22. Percent of Red losses to mech organization TOW vehicles in position defense.

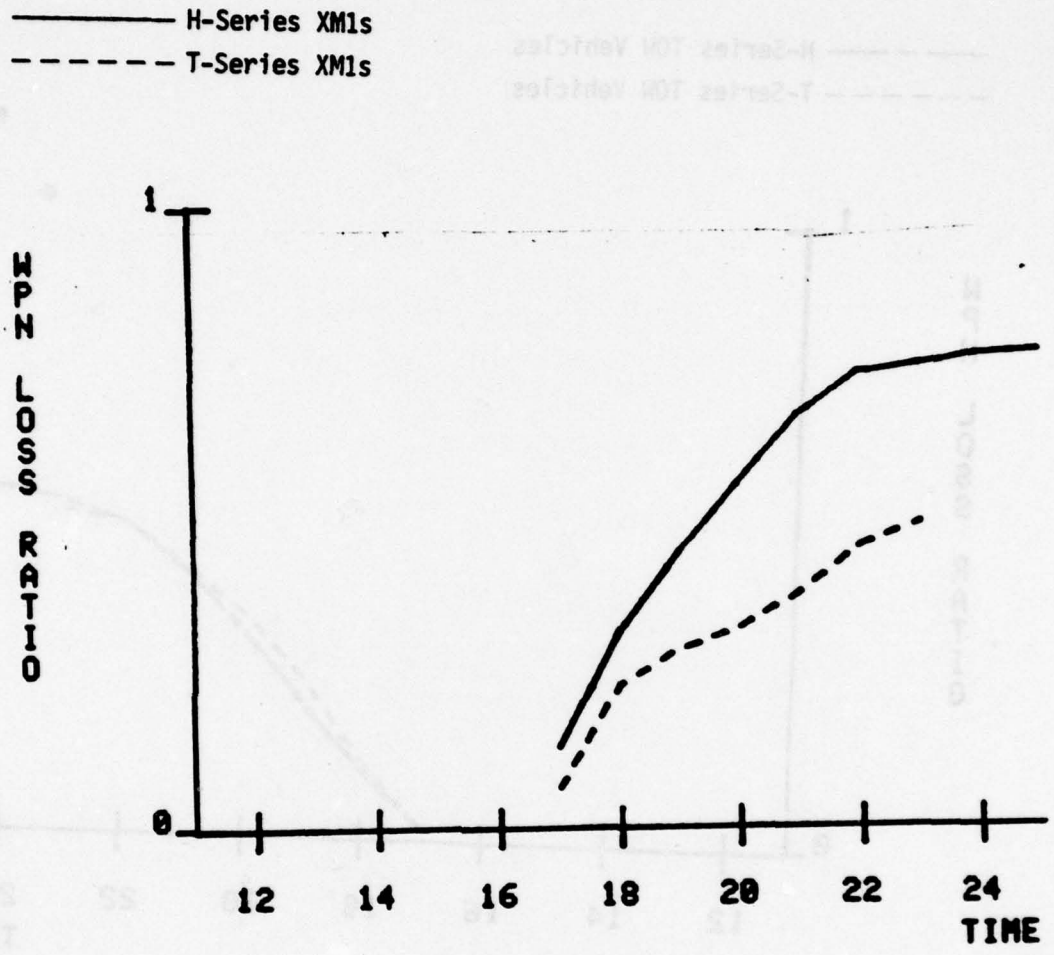

Figure 23. Weapon loss ratios for mech organization XM1s in position defense.

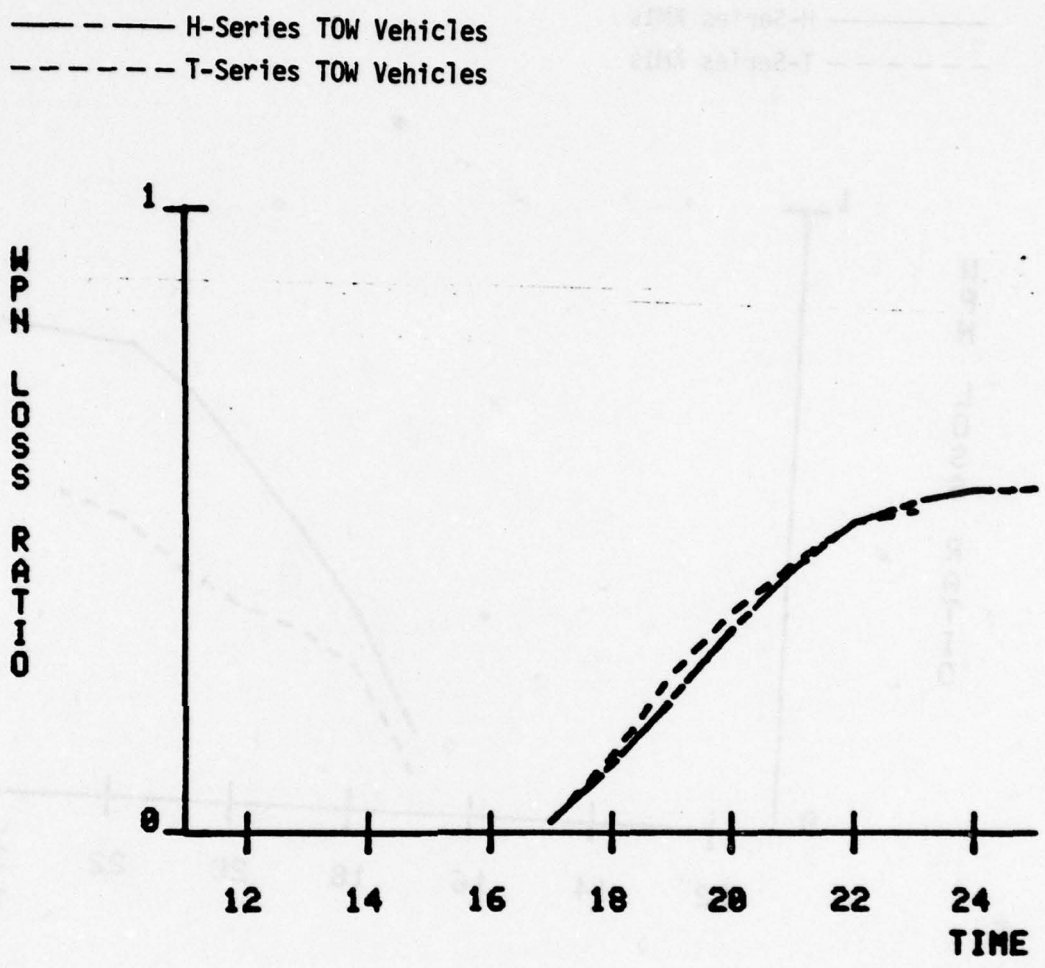

Figure 24. Weapon loss ratios for mech organization TOW vehicles in position defense.

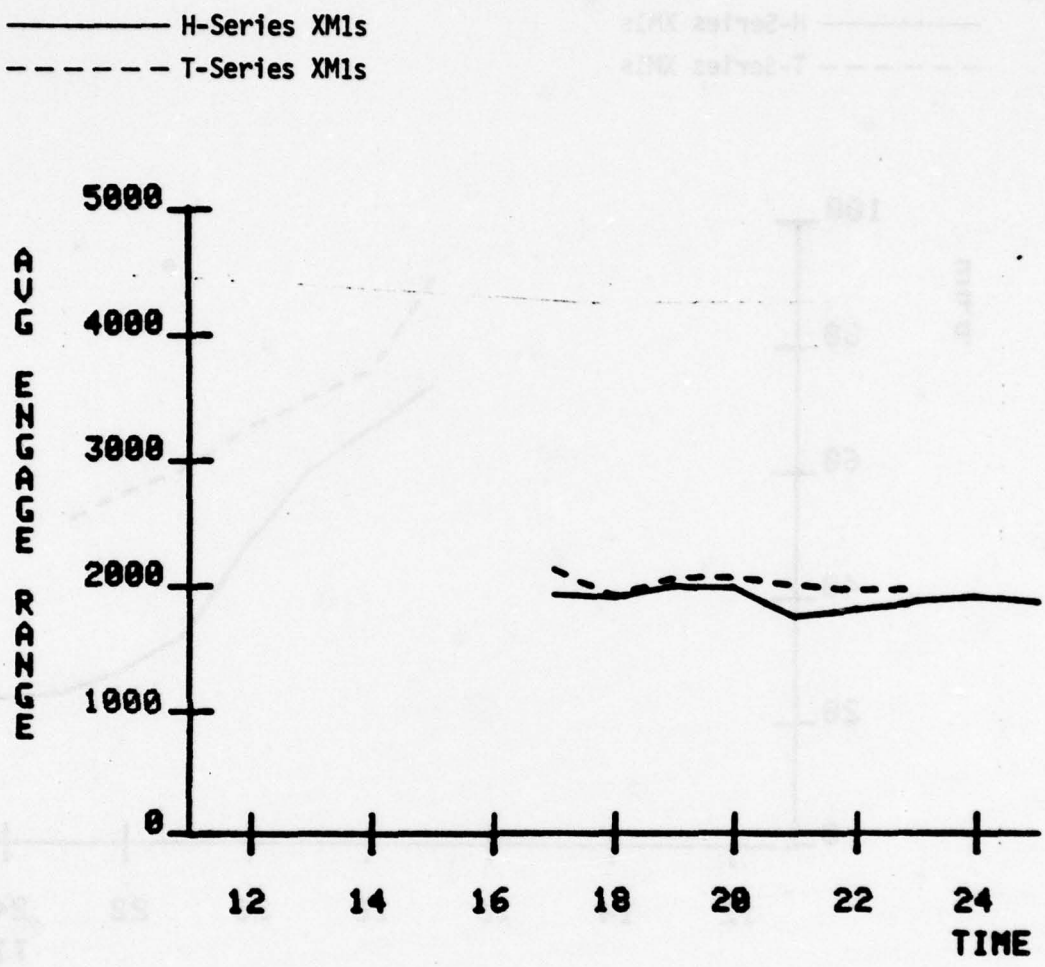

Figure 25. Average engagement ranges for mech organization XM1s in position defense.

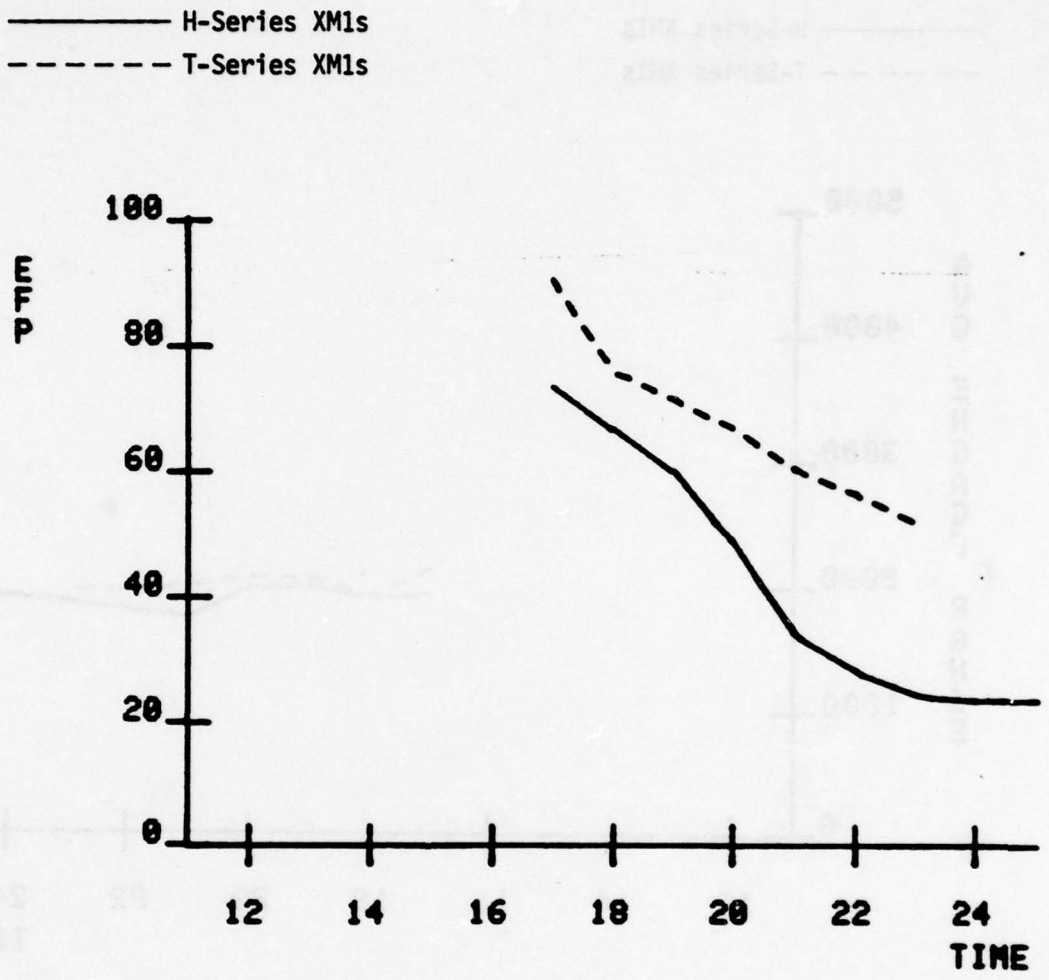

Figure 26. Effective firepower percentage for mech organization XM1s in position defense.

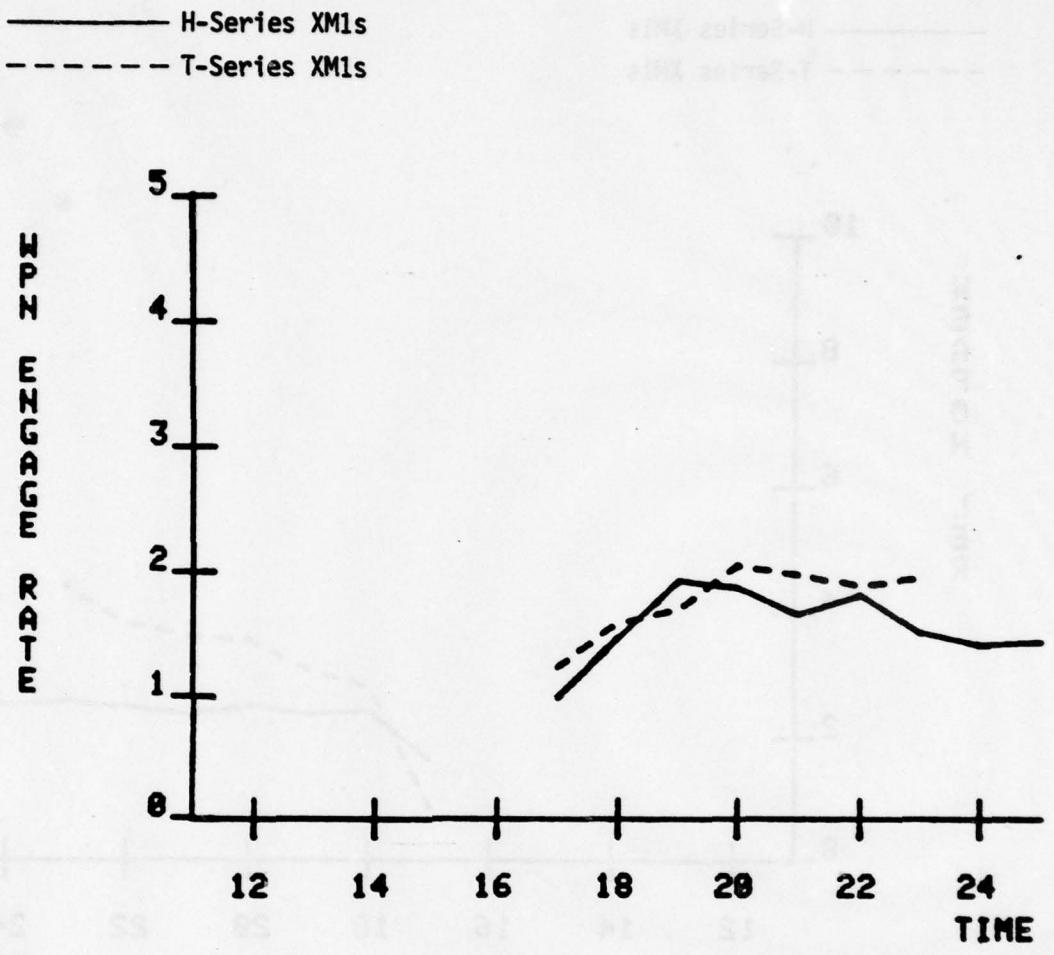

Figure 27. Weapon engagement rates for mech organization XM1s in position defense.

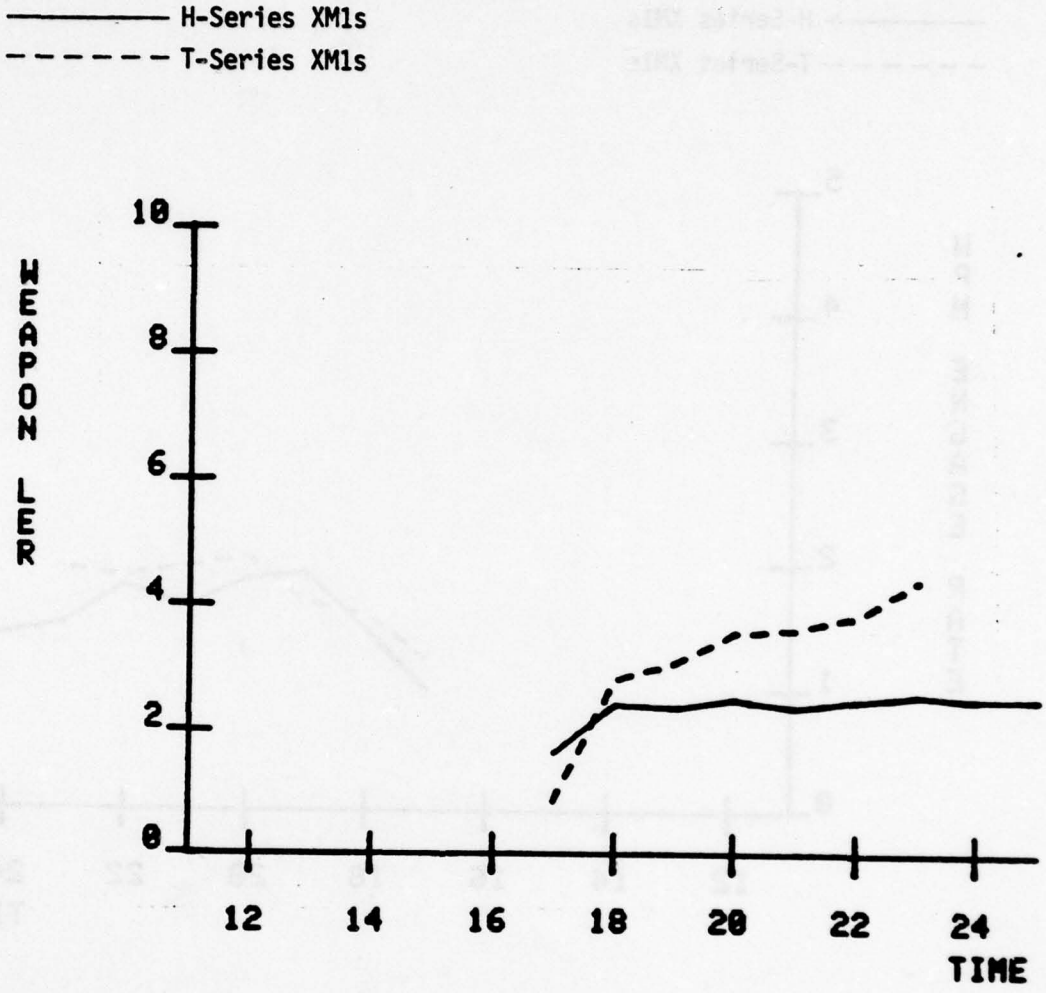

Figure 28. Weapon LERs for mech organization XM1s in position defense.

c. Deliberate Attack Comparisons. These scenarios placed each alternative organization in the position of conducting an offensive operation against a Red reinforced motorized rifle company. The key factor for analysis in these scenarios was determined to be an organization's ability to bring to bear as much of its firepower as possible on the enemy force. The following subparagraphs discuss the ability of two tank organizations and two mech organizations to maneuver their firepower effectively.

(1) H-series versus T-series tank comparisons.

(a) Overall combat effectiveness. The differences between the LERs achieved by each force and the times in which they were achieved were again found in the statistical analysis to be numerically significant. Figure 29 depicts the time relationships that existed between the LERs attained by the two forces. As can be seen from this plot, the T-series tank organization was noticeably more effective during the tenth through the thirteenth minutes of combat than the H-series organization. Throughout the remainder of the battle, however, the LER of the T-series organization was only marginally higher than the H-series. Figures 30 and 31 show the average number of Red and Blue losses experienced in the gaming of these scenarios, respectively. It is apparent from figure 30 that the H-series tank organization killed Red vehicles earlier in its scenario than did the T-series tank organization. In fact, the H-tank organization maintained a higher kill rate throughout the battle, although at the end of the battle there was little difference between the total Red losses. This superior performance by the H-series organization can be directly attributed to the differences in the tactical mobility rates used in the gaming of each organization. These mobility data, as discussed in appendix A, were derived from data collected during the DRE Battalion Field Test, which found that the H-series vehicles maneuvered at greater rates than the T-series vehicles. The result of using these rates in the CARMONETTE gaming was that the vehicles of the H-series organizations were able to move at higher speeds than the T-series vehicles. Accordingly, the H-series organizations got into the battle faster and were able to inflict losses on the Red force sooner than the T-series organizations. The plots of the Blue losses shown in figure 31 also illustrate the disparity in the mobility rates of the two organizations. Noteworthy, however, is the fact that the losses suffered by the T-series tank organization were an average of 3.16 armored vehicles fewer than the H-series organization. Thus, the principal reason for the significant difference observed in LER is the better survivability of the armored vehicles in the T-series tank organization. The SMFRD plots for the two organizations are presented in figure 32. It is apparent from the SMFRD plots that both organizations were able to defeat the opposing force. The value of the T-series SMFRD was numerically greater than the H-series SMFRD, which indicates that the combat effectiveness of the T-series organization was greater than that of the H-series organization.

(b) Weapon system performance. Since the key factor in these offensive scenarios was an organization's ability to effectively maneuver its firepower to bring as much as possible to bear on the enemy, the measure of performance first analyzed was effective firepower percentage (EFP). In tables 25 and 26 the statistical analysis of the EFP for XM1s and TOW vehicles found that the T-series organization was able to get 10 percent more of its XM1s and 3 percent more of its TOW vehicles into the battle. Translating the percentages into numbers of weapon systems, the T-series tank organization fought the battle with an average of 15.3 XM1s and 15.4 TOW vehicles, whereas the H-series organization fought with an average of 16.3 XM1s and only 9.4 TOW vehicles. Thus, the T-series organization was able to maneuver into the battle and fight with an average of 5.0 more major weapon systems than the H-series tank organization.

1. Comparisons of the remaining performance parameters also presented in tables 25 and 26 found similarities in the contribution of the XM1s to the effectiveness of their respective organizations. The XM1s of the two organizations accounted for a larger percentage of the Red losses than did the TOW vehicles. As shown in figures 33 through 36, the XM1s of the two organizations had about the same weapon engagement rates, weapon loss ratios, average engagement ranges, and loss exchange ratios.

2. There was, however, a distinct difference in the contributions to effectiveness of the TOW vehicles. The differences noted were between the weapon loss ratios (presented in figure 37), the average engagement ranges (presented in figure 38), and specifically between the loss exchange ratios for the TOW vehicles of the two organizations (presented in figure 39).

a. Examination of these differences found that the superior performance of the T-series TOW vehicles was primarily due to the T-series infantry combat vehicle (IFV) performance. Figure 40 shows the differences in LER observed for all the T-series TOW vehicles. It is apparent from the figure that the IFVs were the primary contributors to the superior performance of the T-series TOW vehicles. A comparison of the T-series and H-series IFVs found significant differences existing between the weapon loss ratios as shown in figure 41, average engagement ranges as shown in figure 42, and the respective LERs as shown in figure 43. This exceptional performance by the T-series IFVs, however, is counter-intuitive to the expectations of TOW vehicles in the offense.

b. Further analysis established that the seemingly high T-series IFV LER was attributable to the way CARMONETTE allocated artillery/mortar fires. CARMONETTE requires that targets for "on-call" fire support be prioritized by target class (weapon system). In these offensive tank scenarios first priority for Red fire support was given to tank targets, since tanks were the most abundant weapons and were considered to present the greatest threat to the Red maneuver systems. Because of this, the vast majority of the Red artillery/mortars were fired in the CARMONETTE runs at tank targets. Since the H-series tank

organization was task organized into tank heavy company teams, which collocated the XM1s and TOW vehicles, the suppressive effects from the impacting Red artillery/mortar rounds were experienced by both XM1s and TOW vehicles. The T-series tank organization, however, by doctrine was fought with pure companies. Accordingly, most of the Red fire support was directed against the two pure tank companies with few, if any, rounds impacting around the mech company IFVs. Thus, the T-series IFVs experienced little suppressive effects from the Red fire support systems and, therefore, were able to attain the observed superior measures of performance.

(c) Summary. Careful examination of the gaming results uncovered a problem within CARMONETTE that influenced the outcomes in favor of the T-series tank organization. The degree of influence is uncertain. Thus, although the statistical analysis found the difference in combat effectiveness to be numerically significant, the SMFRD plots show the T-series tank organization as only marginally more combat effective. Thus, it is questionable in a practical sense whether the T-series organization was significantly more combat effective.

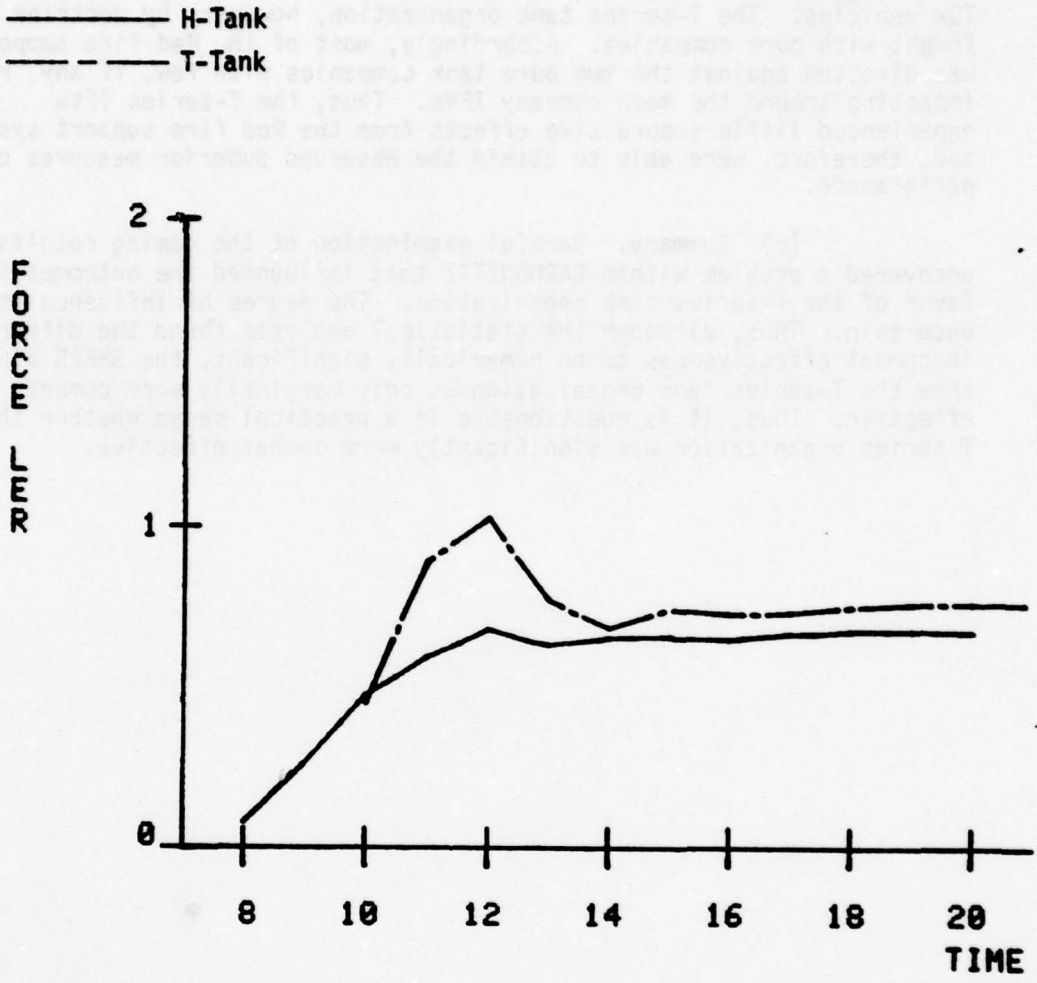

Figure 29. Force loss exchange ratios of tank organizations in deliberate attack.

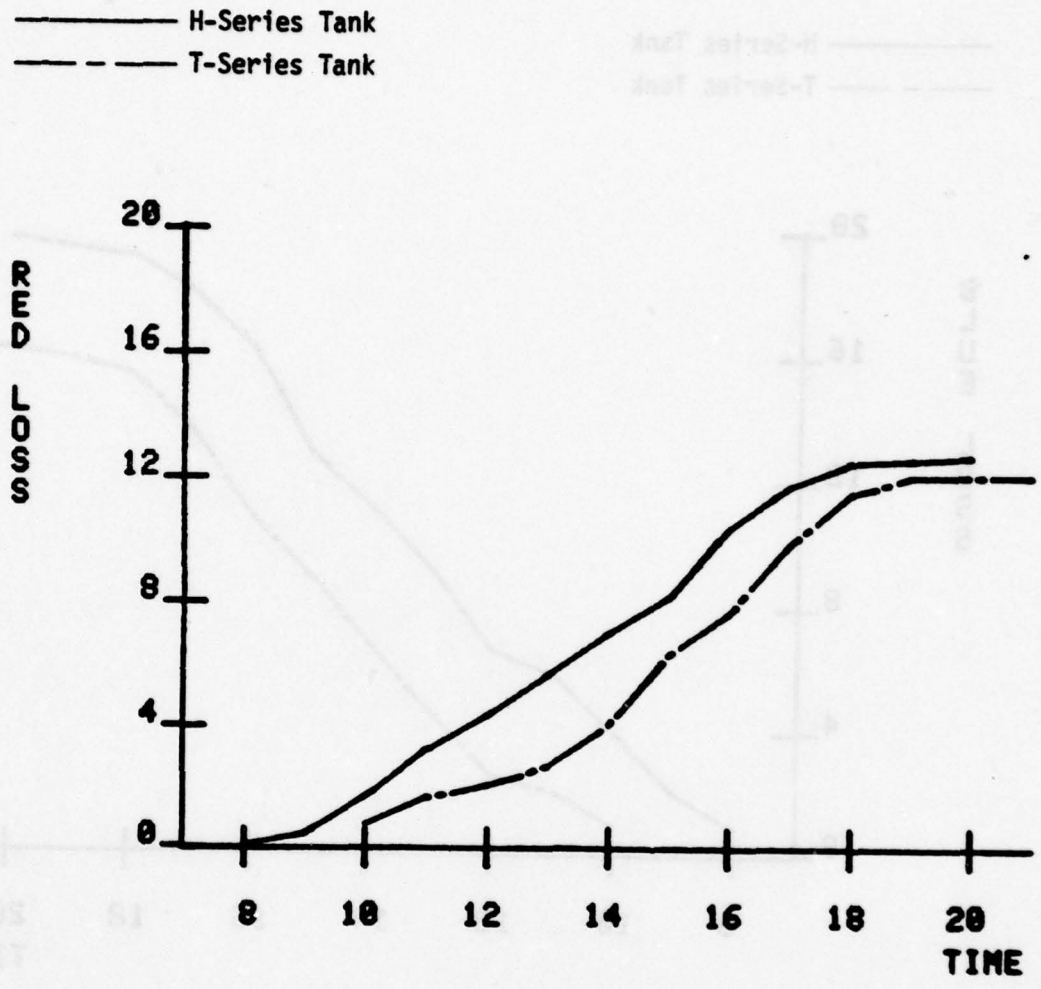

Figure 30. Red losses to tank organizations in deliberate attack.

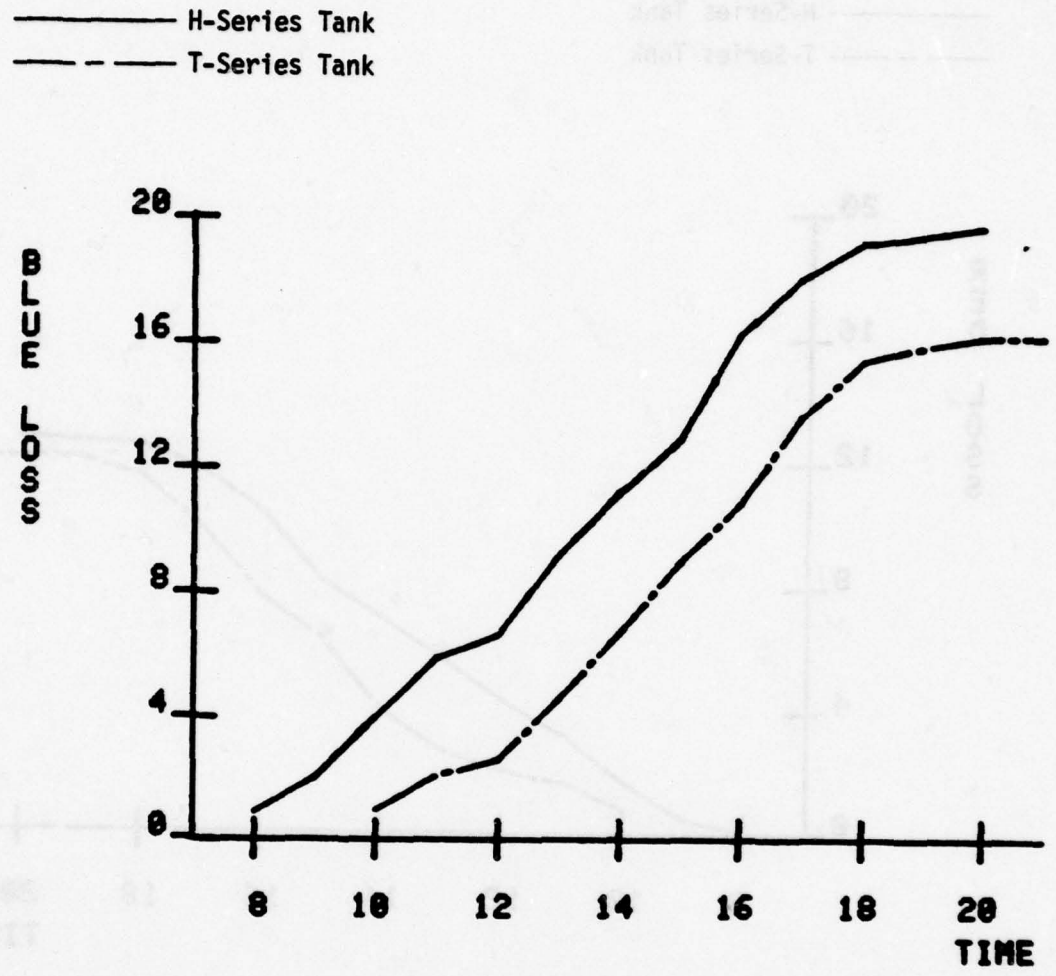

Figure 31. Blue losses incurred by tank organizations in deliberate attack.

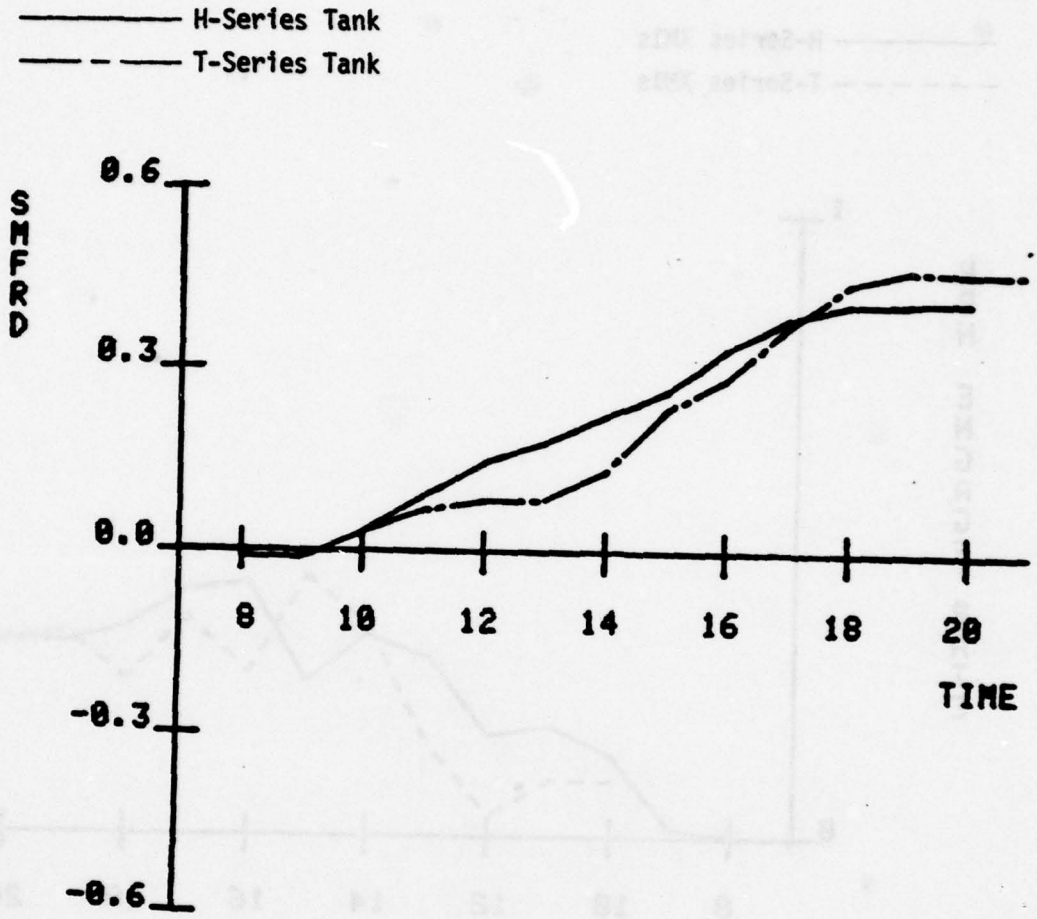

Figure 32. Surviving maneuver force ratio differentials for tank organizations in deliberate attack.

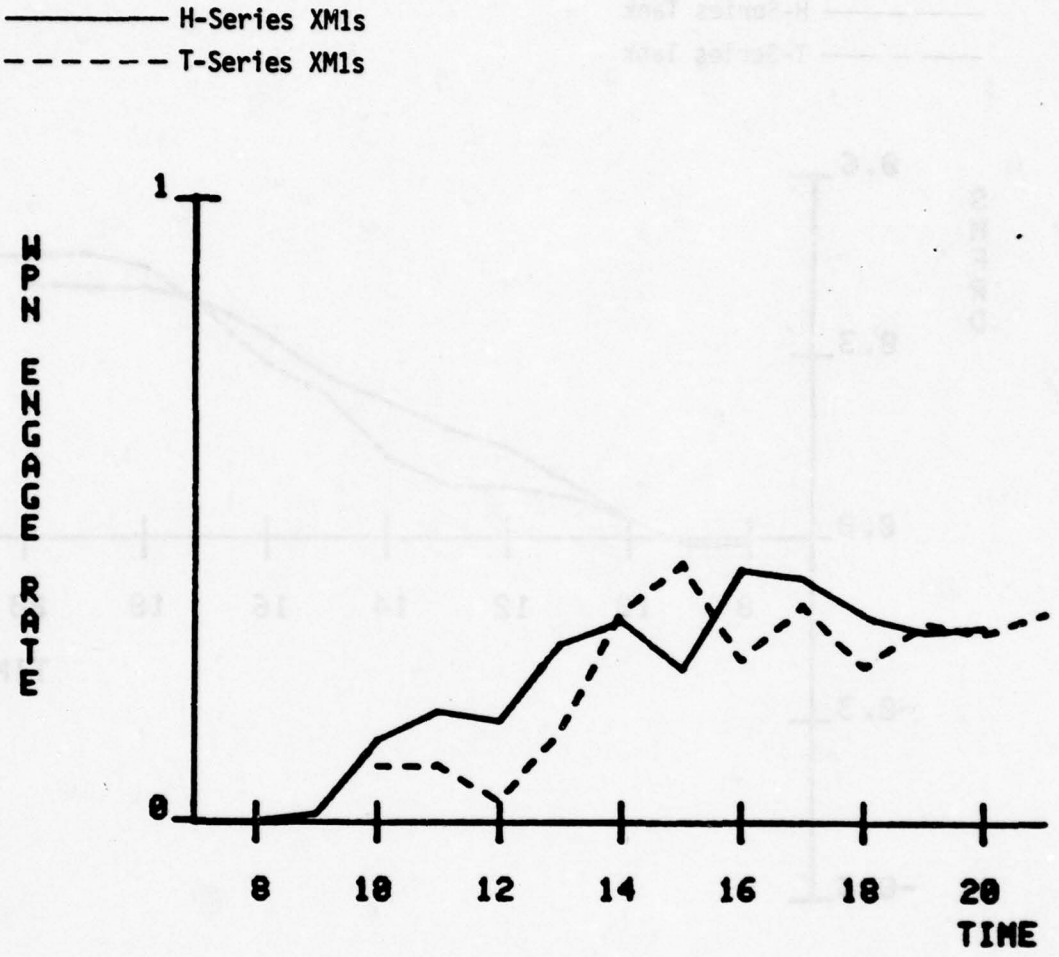

Figure 33. Weapon engagement rates for tank organization XM1s in deliberate attack.

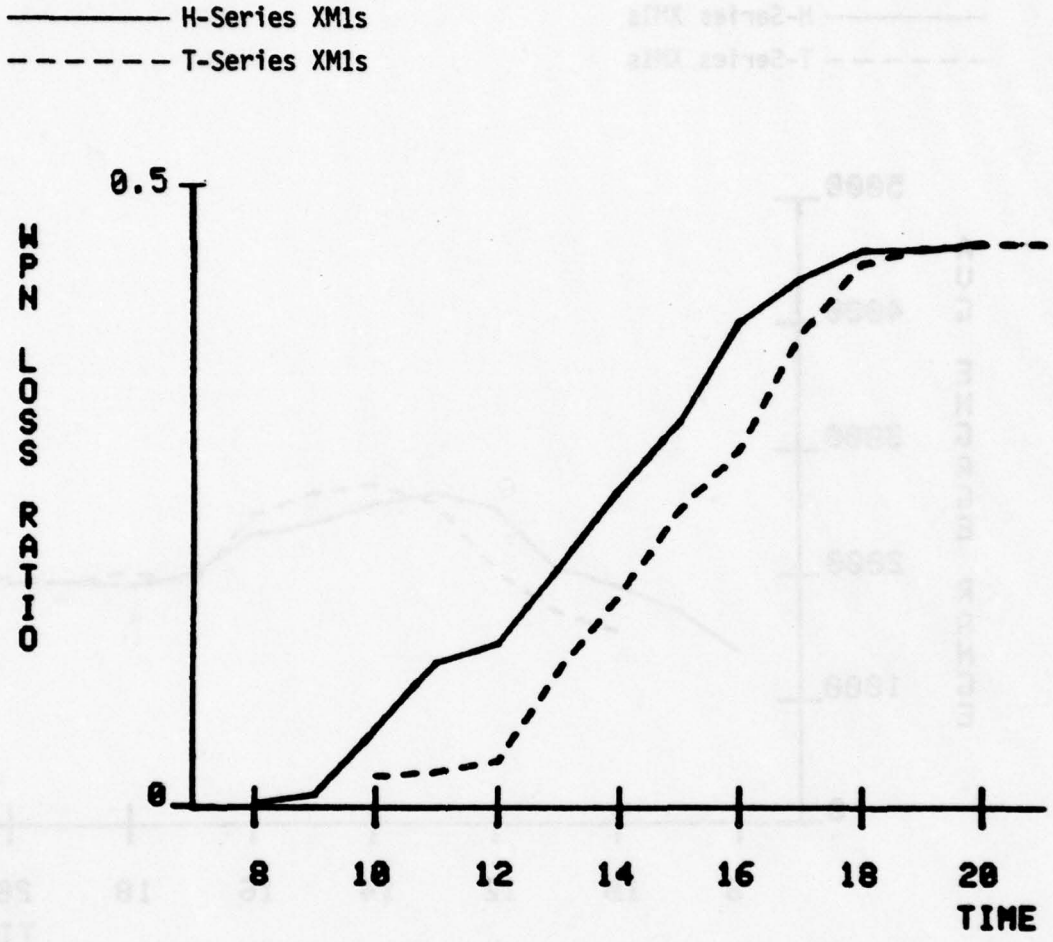

Figure 34. Weapon loss ratios for tank organization XM1s in deliberate attack.

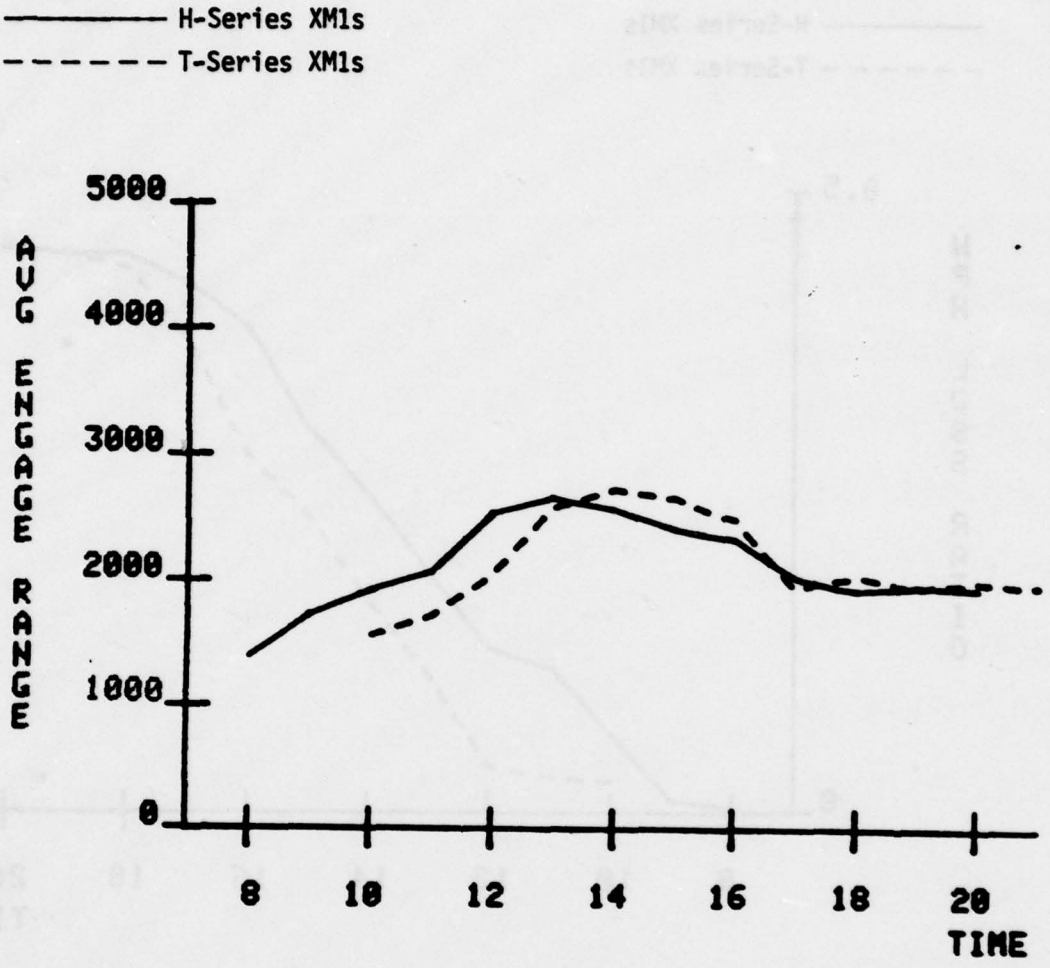

Figure 35. Average engagement ranges of tank organization XM1s in deliberate attack.

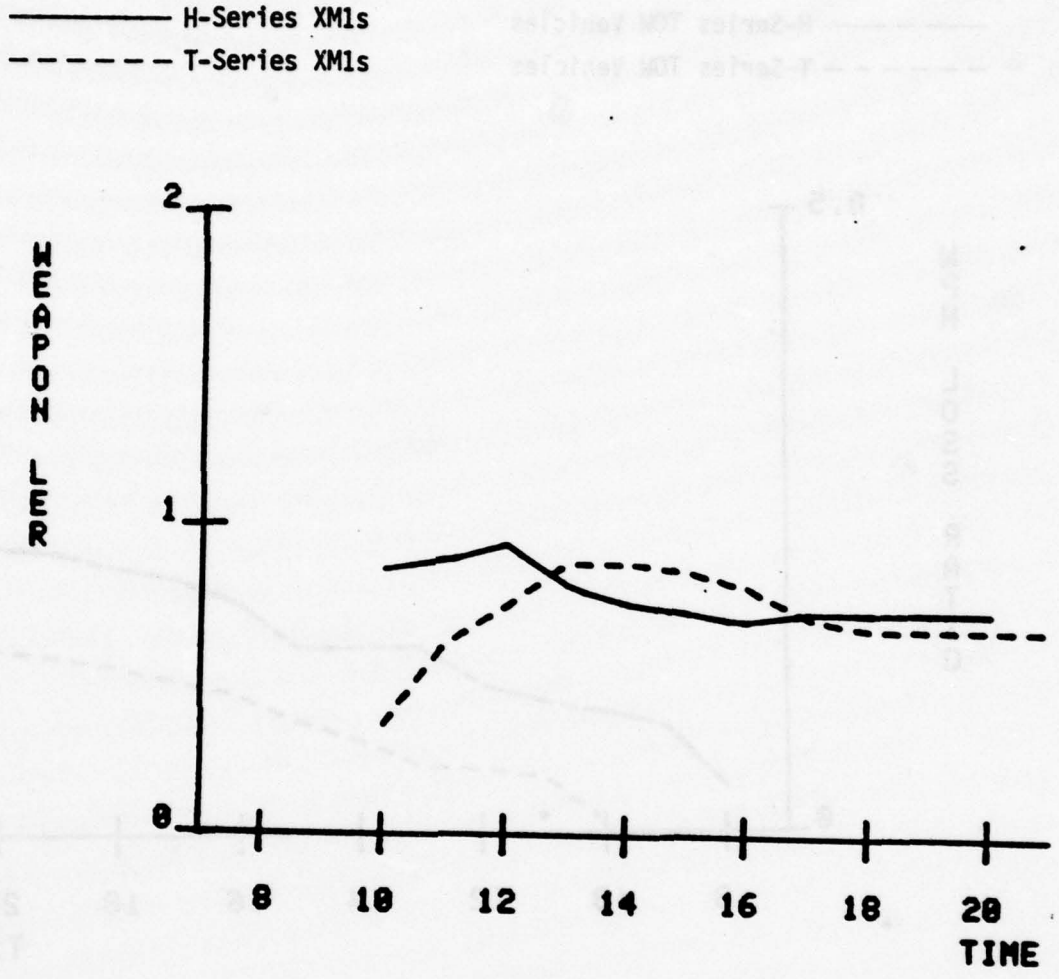

Figure 36. Loss exchange ratios for tank organization XM1s in deliberate attack.

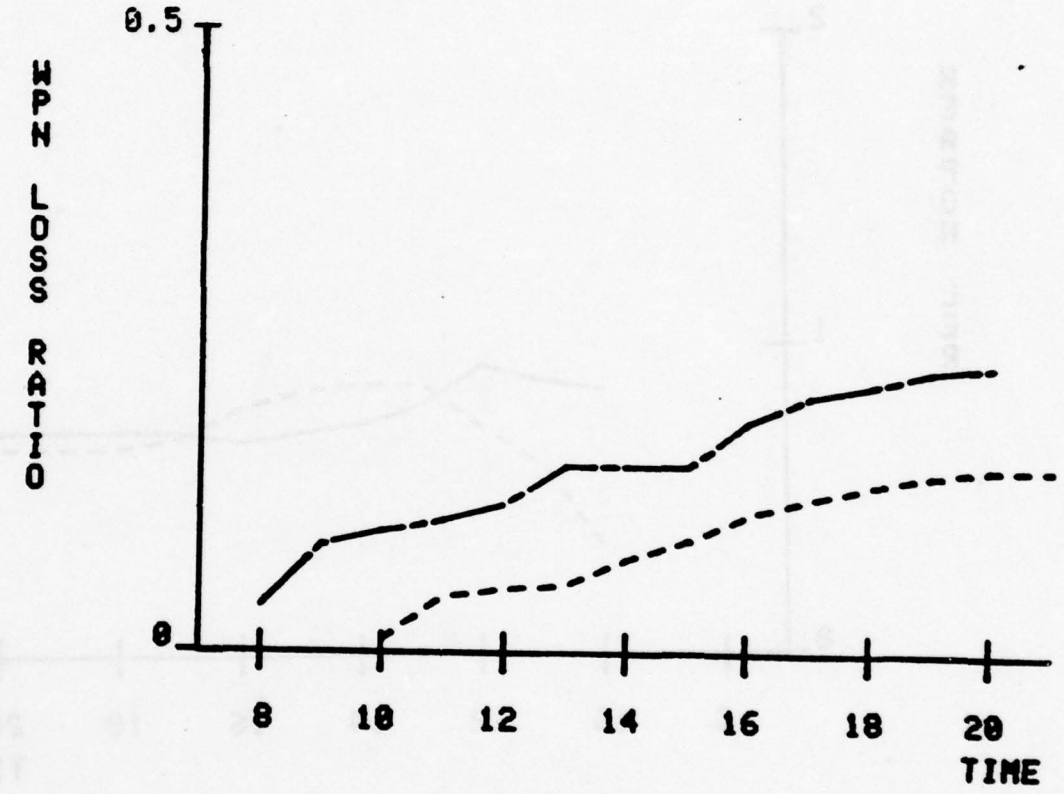

Figure 37. Weapon loss ratios of tank organization TOW vehicles in deliberate attack.

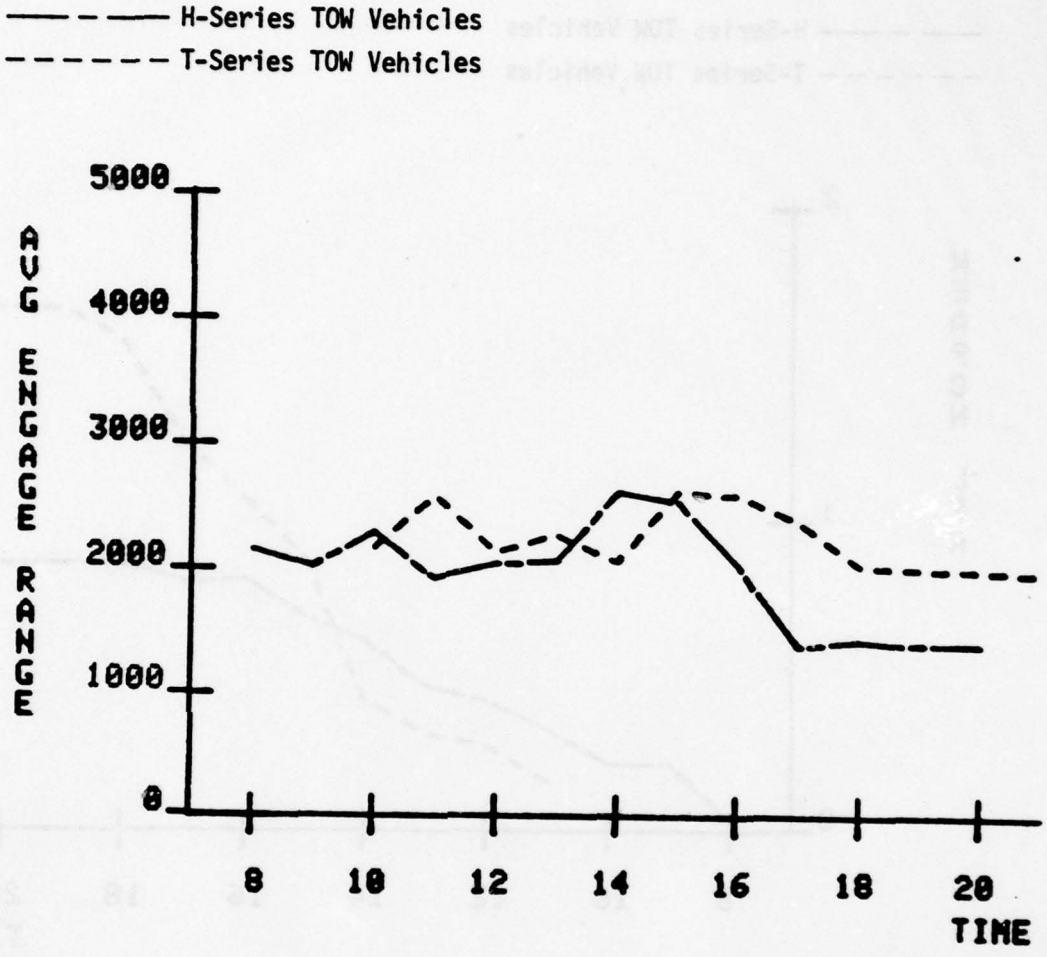

Figure 38. Average engagement ranges of tank organization TOW vehicles in deliberate attack.

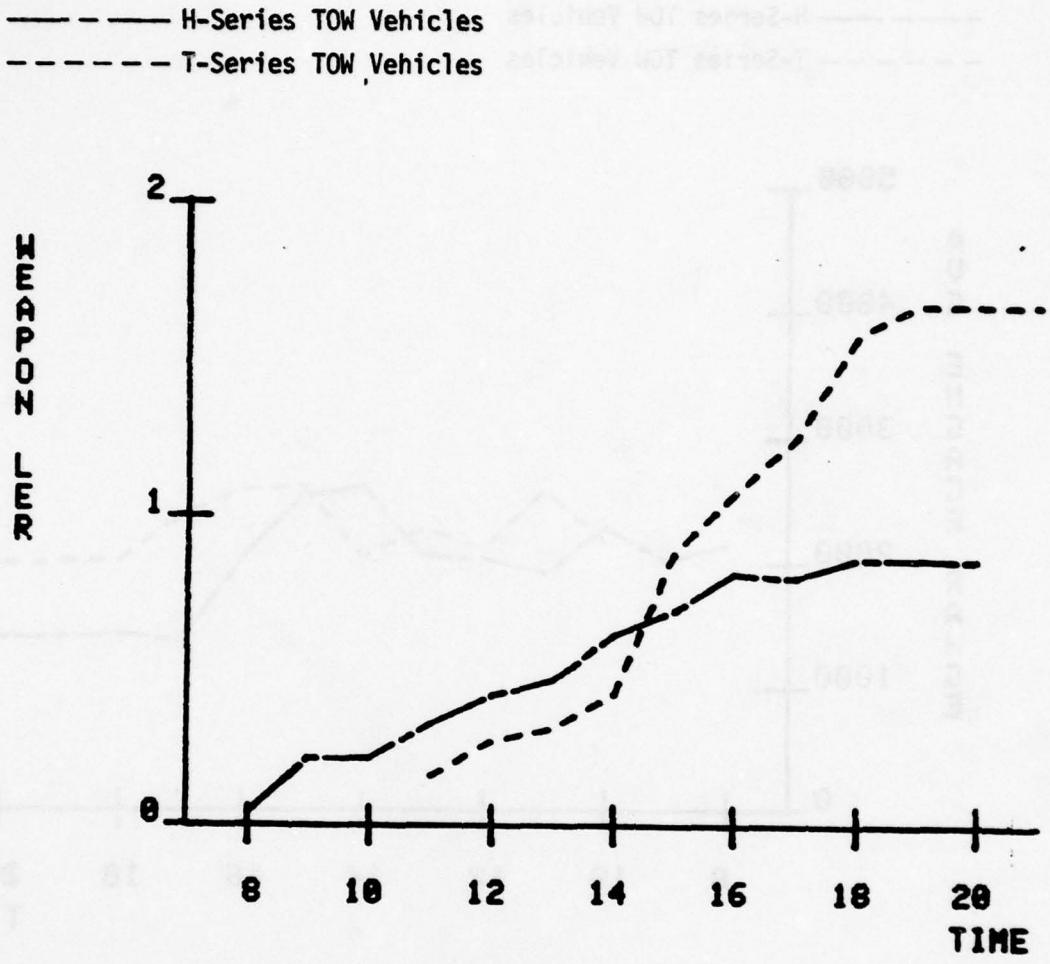

Figure 39. Loss exchange ratios for tank organization TOW vehicles in deliberate attack.

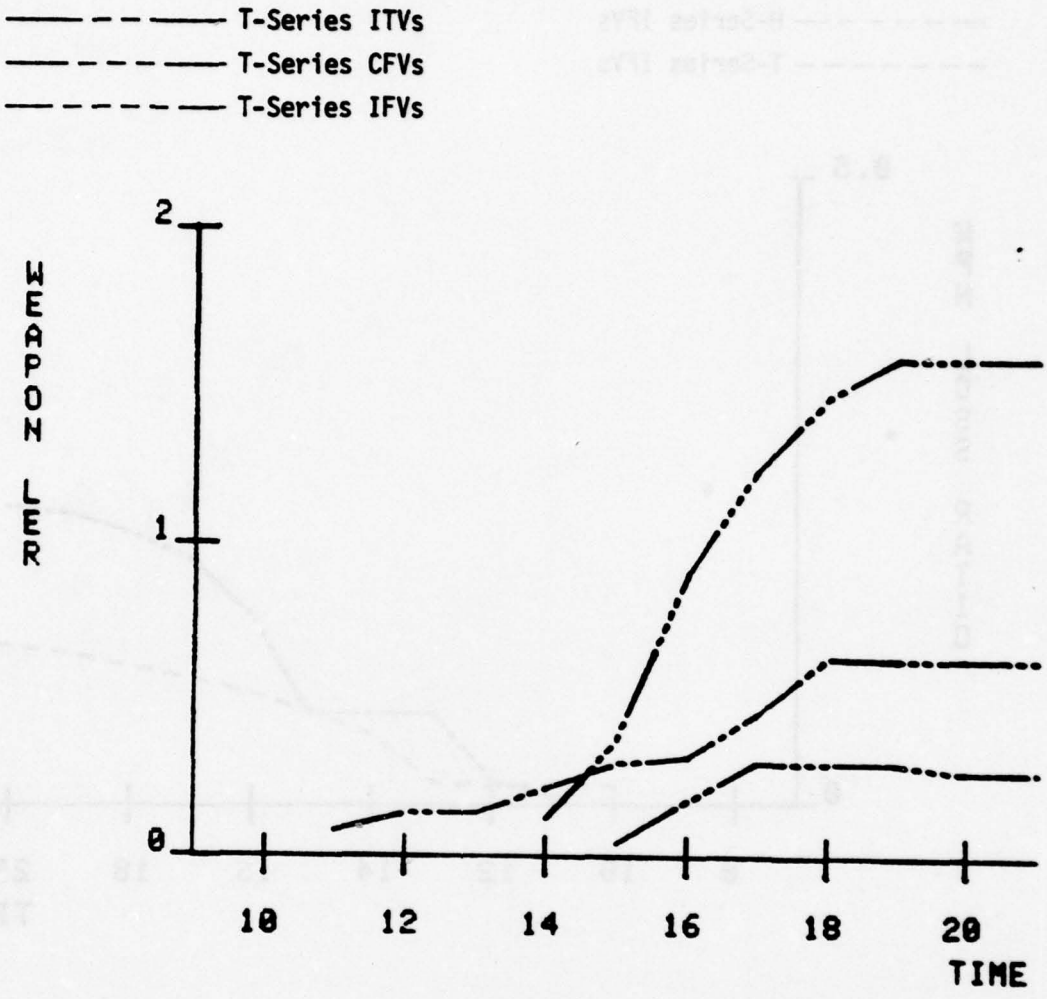

Figure 40. Loss exchange ratios of T-series tank organization TOW vehicles in deliberate attack.

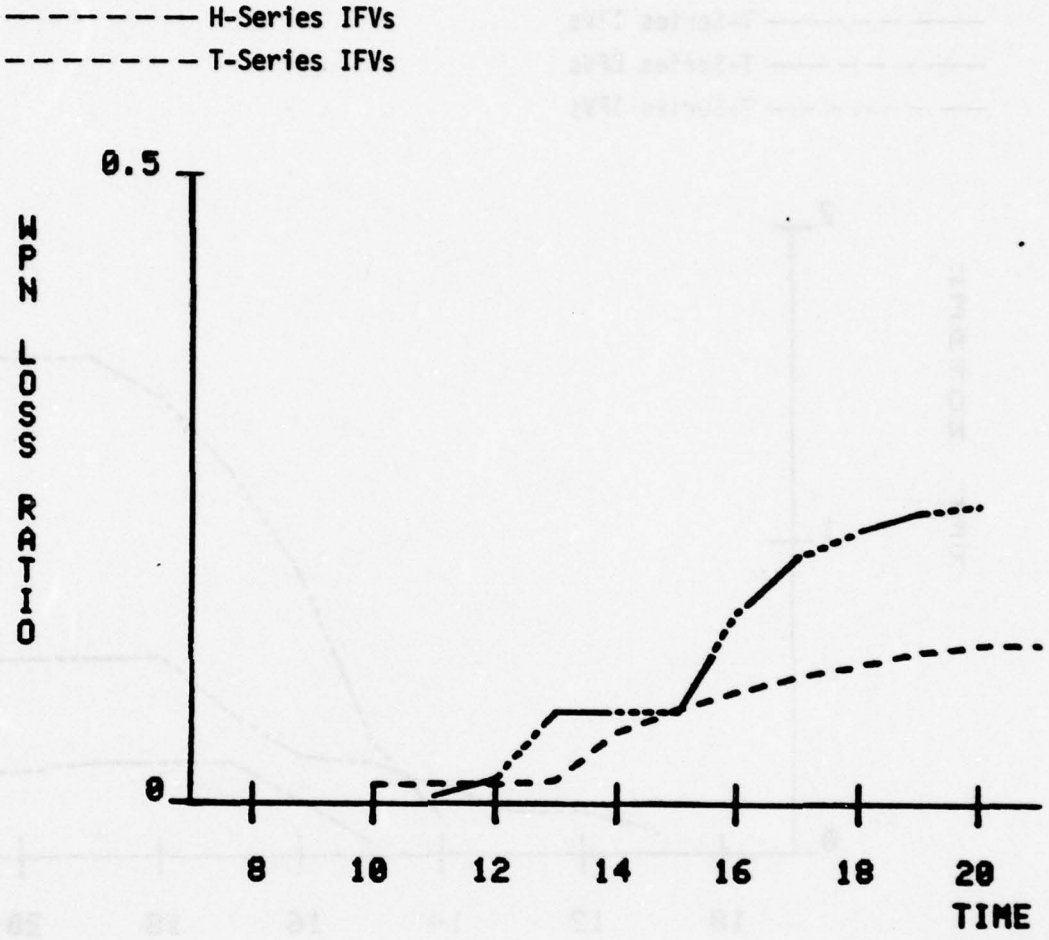

Figure 41. Weapon loss ratios for tank organization IFVs in deliberate attack.

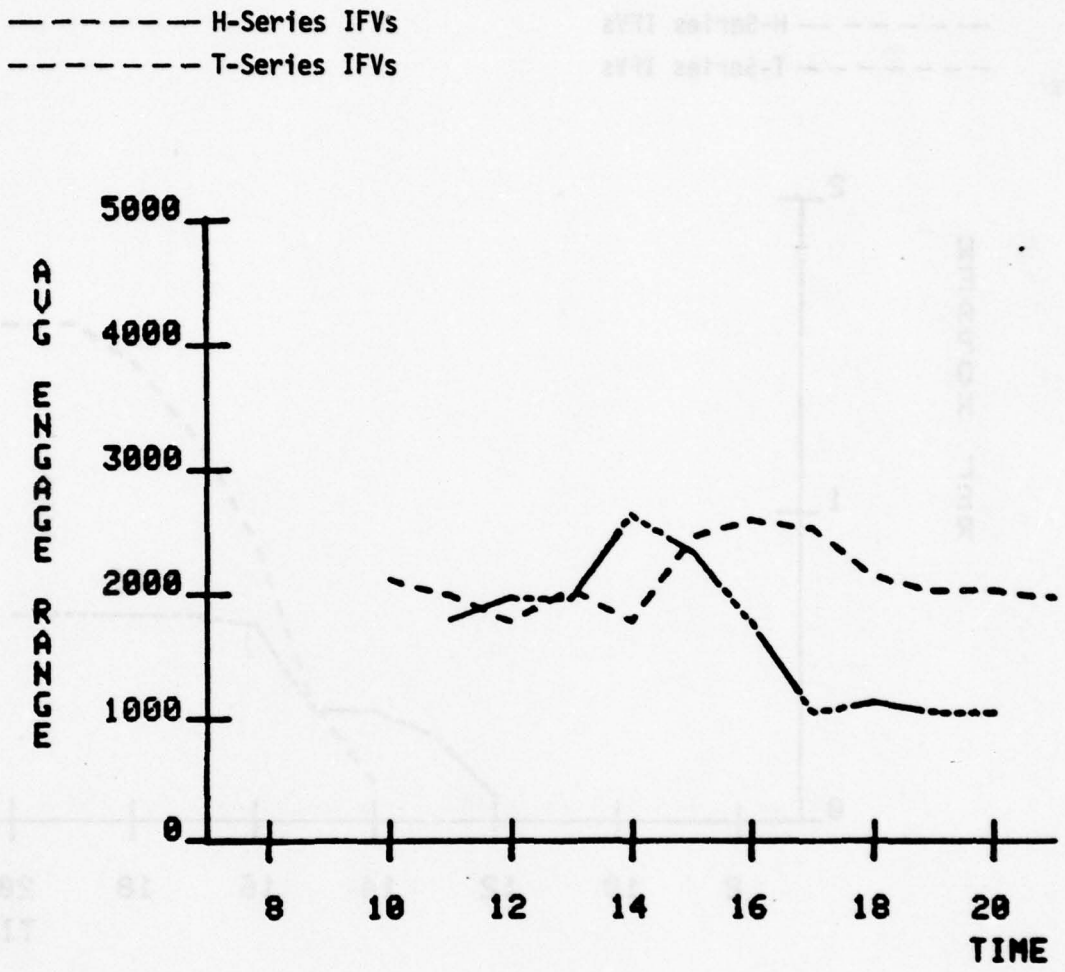

Figure 42. Average engagement ranges of tank organization IFVs in deliberate attack.

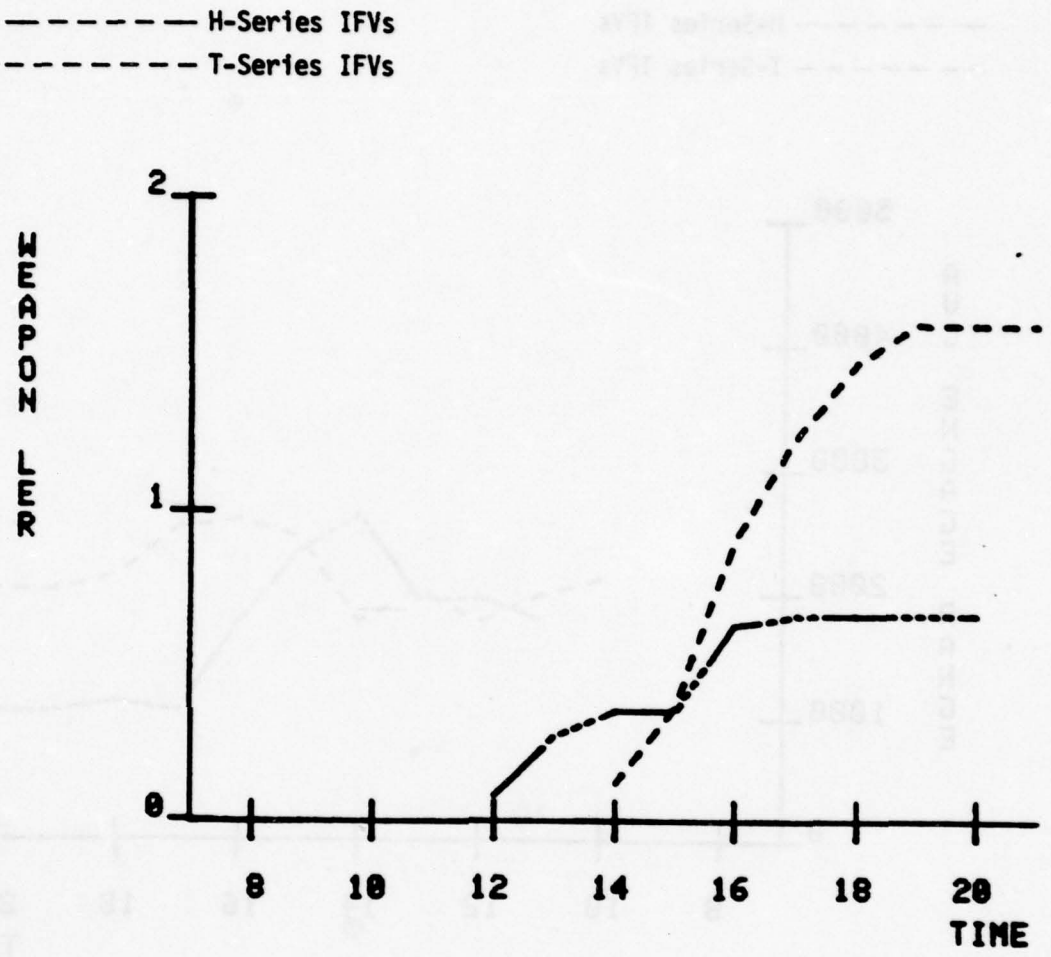

Figure 43. Loss exchange ratios for tank organization IFVs in deliberate attack.

(2) H-series versus T-series mech comparisons.

(a) Overall combat effectiveness. The gaming of the mech deliberate attack scenarios provided results that were also found in the statistical analysis to be multivariate statistically significant with respect to force LER and time. Figure 44 contains time plots of the LERs achieved by each mech organization. The plots show the T-series LER to be basically greater than the H-series LER. The total number of Red and Blue losses are presented in figures 45 and 46, respectively. The total Red losses at the end of the battles, as shown in figure 45, were the same for each organization. As in the results of the tank offensive scenarios, the H-series mech organization appeared to be able to kill Red faster than the T-series mech organization. As before, this is directly attributable to the faster H-series mobility rates. This characteristic time lag of the T-series behind the H-series is also present in the Blue loss plots of figure 46, which in addition shows that the T-series mech organization lost an average of 4.28 fewer armored vehicles than the H-mech organization. Thus, the observed difference between the LERs of the two organizations is attributable to the increased survivability of the T-series weapon systems. The SMFRD plots for the mech organizations are presented in figure 47. The SMFRD plots indicate that both organizations won their respective battles. The T-series organization ended its battle with a numerically higher SMFRD than the H-series organization. Since both organizations killed the same percent of the Red force, this indicates that the T-series was more combat effective because a greater percentage of its force survived.

(b) Weapon system performance. Since the key factor to success in the offensive scenarios has been assessed to be an organization's ability to maneuver its firepower into battle, the effective firepower percentage (EFP) was again the first measure of performance investigated. Tables 33 and 34 of the statistical analysis show that the T-mech organization was able to get 12 percent more of its XM1s and 2 percent more of its TOW vehicles into the battle. Translating into numbers of weapon systems, the T-series organization fought the battle with an average of 8.1 XM1s and 26.4 TOW vehicles, while the H-mech organization fought with 6.2 XM1s and 24.5 TOW vehicles. Thus, the T-series organization fought the battle with an average of 3.8 more major weapon systems than the H-mech organization.

1. TOW vehicle performance. A comparison of performance measures for the mech TOW vehicles as presented in table 34 revealed that they were responsible for the majority of the Red losses. Figure 48 shows that the T-series TOW vehicles were able to surpass the LER of the H-series TOW vehicles during the last 4 minutes of their battle. Since there was no appreciable difference in the weapon engagement rates and the average engagement ranges (shown in figures 49 and 50, respectively), the superior T-series TOW vehicle LER was attributed primarily to their lower average weapon loss ratio. Figure 51 shows that the T-series organization lost 31 percent of its TOW vehicles and the H-series lost 44 percent. The anomaly with the suppression of

IFVs due to limitations in the CARMONETTE fire support allocation procedures experienced in the tank offensive scenarios was also present in these mech offensive runs, but to a much lesser degree since the tanks were not as abundant in this scenario. Inspection of the measures of performance of the IFVs from both organizations indicated little difference between them. Thus, the effect of the CARMONETTE fire support limitation was considered negligible.

2. XM1 performance. Investigation of the XM1 measures of performance at table 33 revealed that their contributions to the overall combat effectiveness of their organization were similar. Little difference was apparent between the MOP of the XM1s other than the weapon engagement rate in which the T-series XM1s averaged .26 and the H-series XM1s averaged .15 engagements per minute per tank. Even though the T-series XM1s engaged at almost twice the rate of the H-series XM1s, there was little difference, except for the aforementioned time lag, in their respective loss exchange ratios as shown in figure 52. In fact, the H-series XM1s, because they achieved a lower weapon loss ratio, were able to attain a slightly higher LER.

(c) Summary. The main contributor to the Red losses in the mech deliberate attack scenarios was found to be the TOW vehicles. This was primarily due to the superiority in number of TOW vehicles as compared to the number of XM1s in each mech organization. The T-series mech organization statistically displayed more overall combat effectiveness than did the H-series mech organization. Nonetheless, examination of the SMFRD plots indicates little practical difference between the outcomes of the battles of the respective organizations.

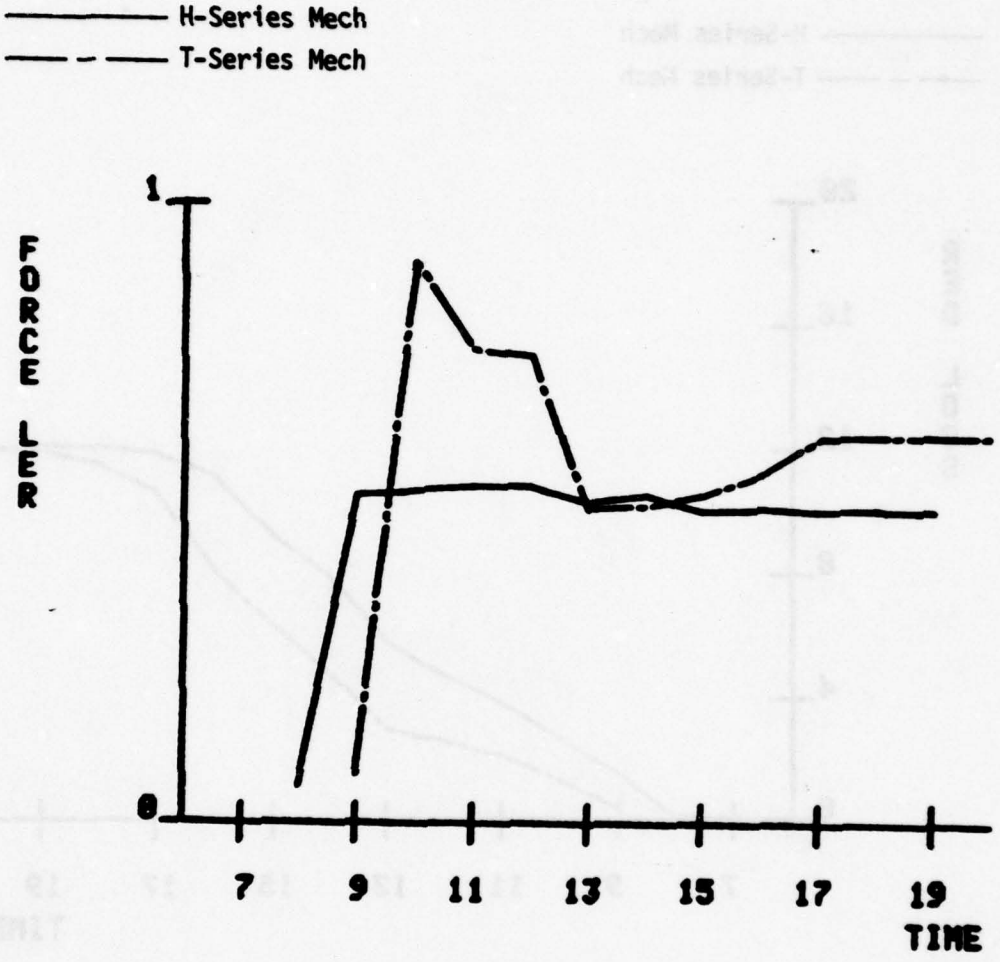

Figure 44. Loss exchange ratios for mech organizations in deliberate attack.

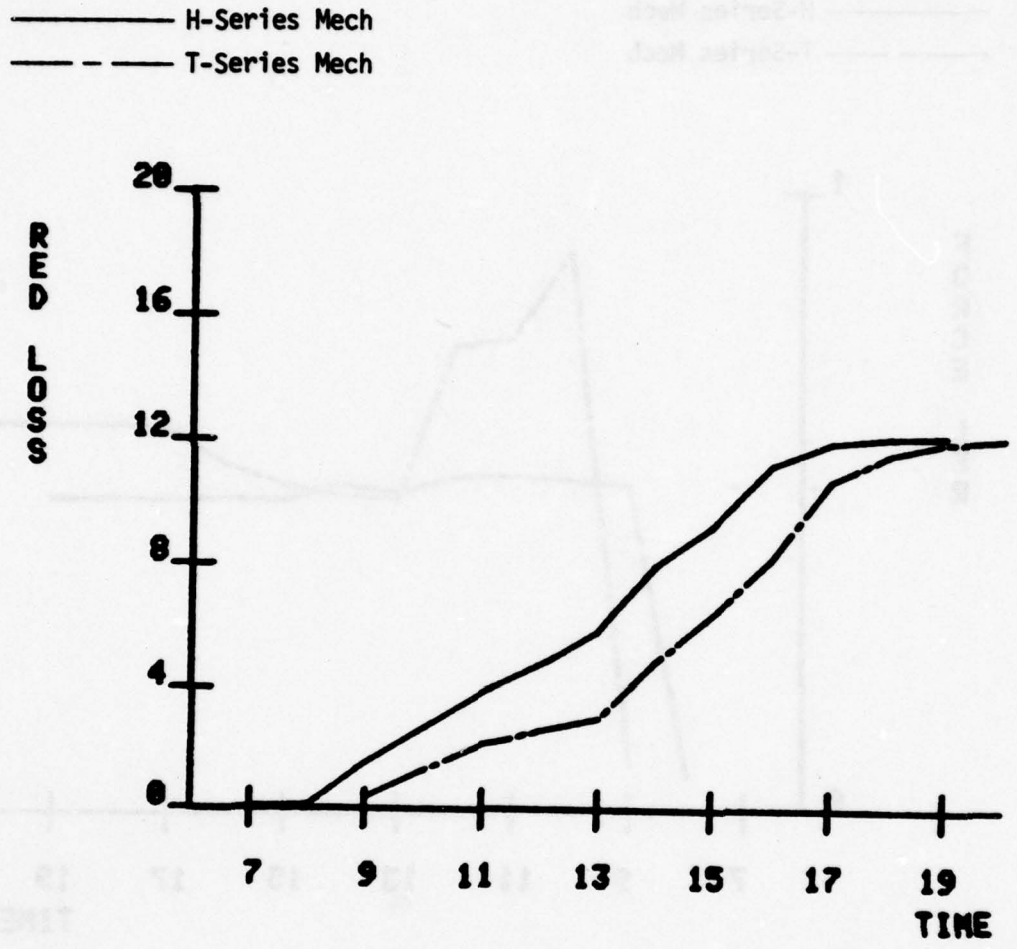

Figure 45. Red losses to mech organizations in deliberate attack.

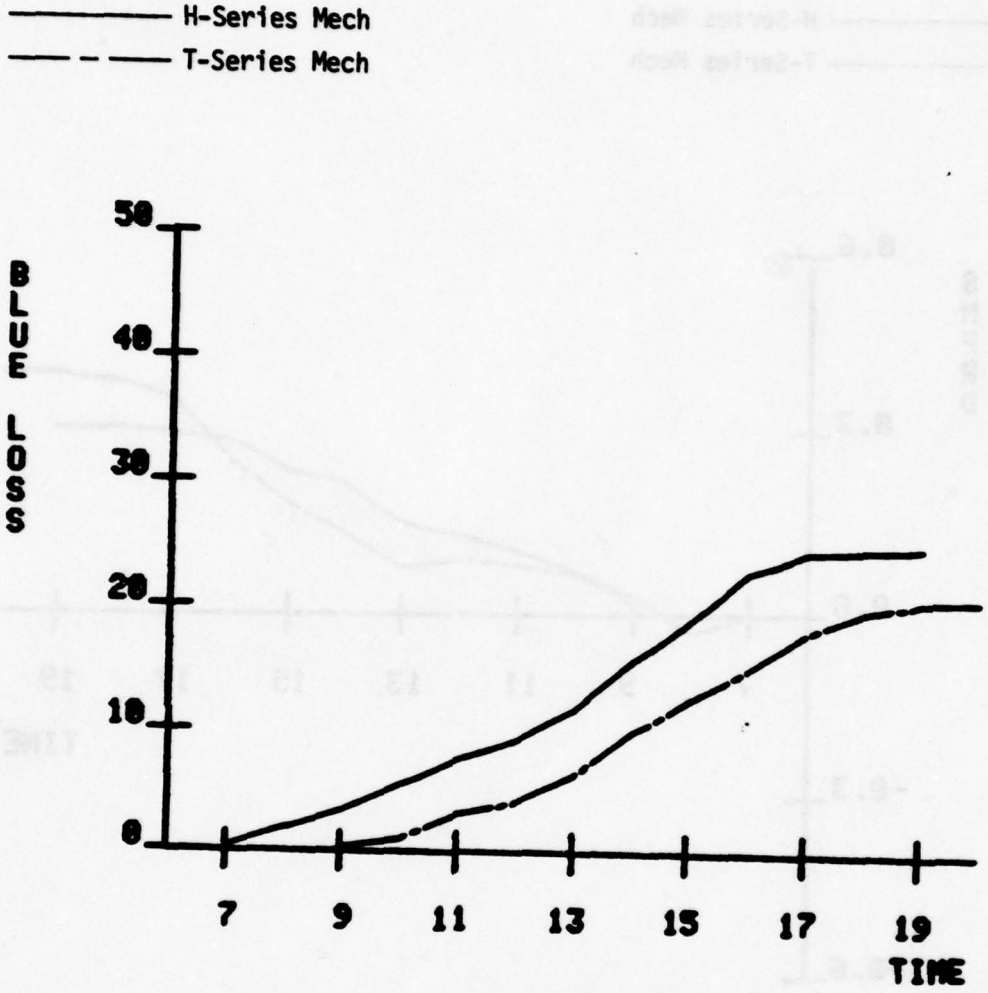

Figure 46. Blue losses incurred by mech organizations in deliberate attack.

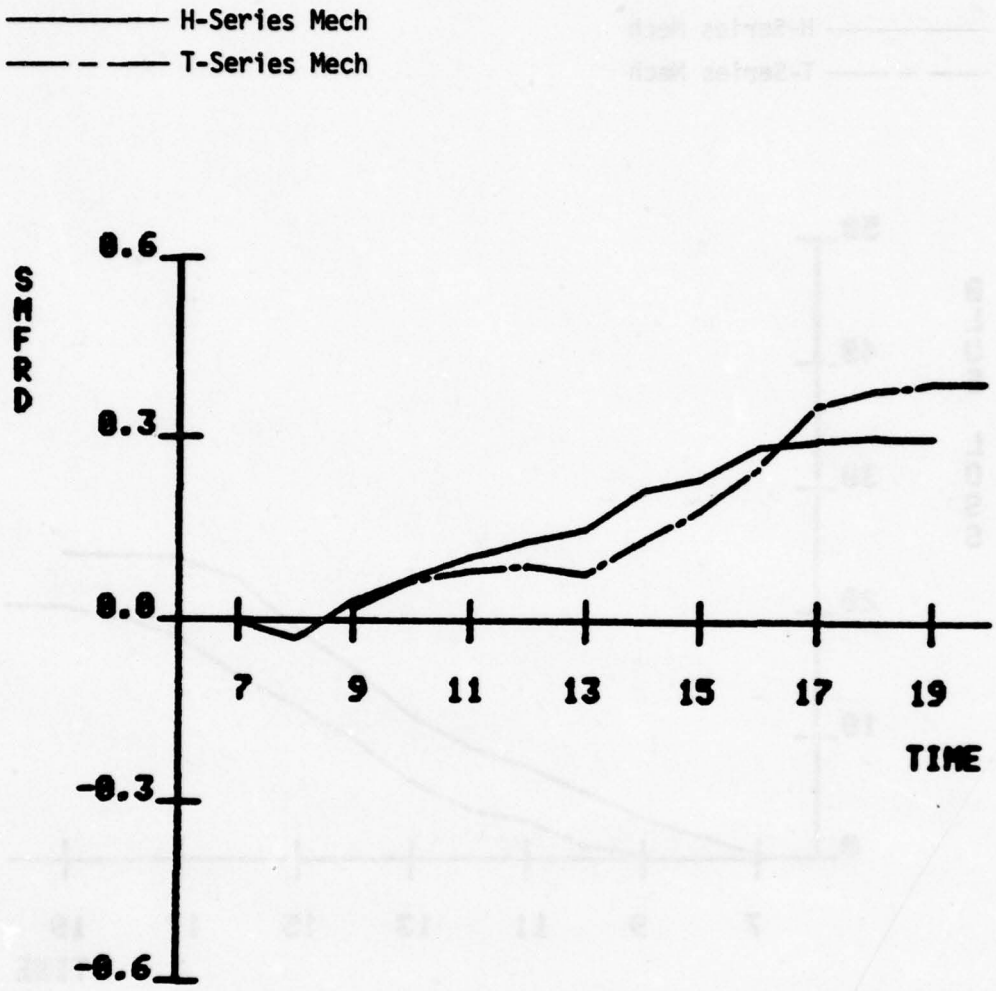

Figure 47. Surviving maneuver force ratio differentials of mech organizations in deliberate attack.

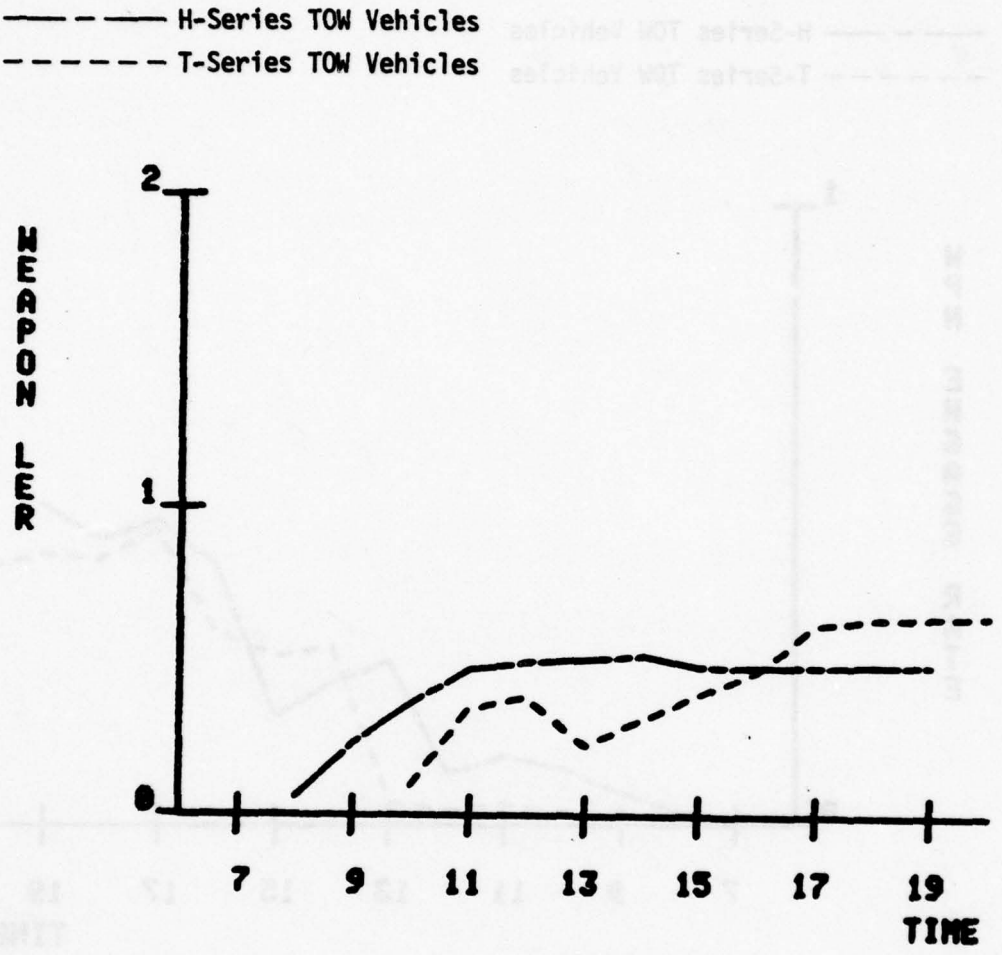

Figure 48. Loss exchange ratios of mech organization TOW vehicles in deliberate attack.

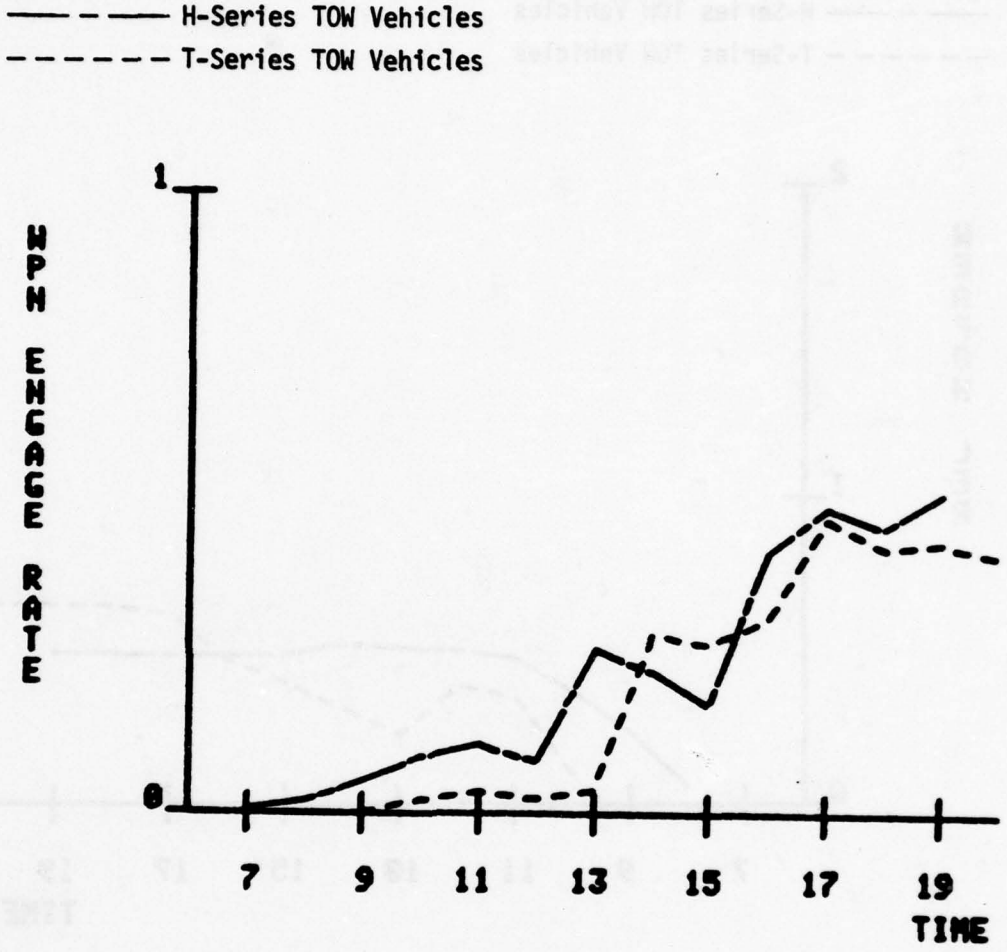

Figure 49. Weapon engagement rates for mech organization TOW vehicles in deliberate attack.

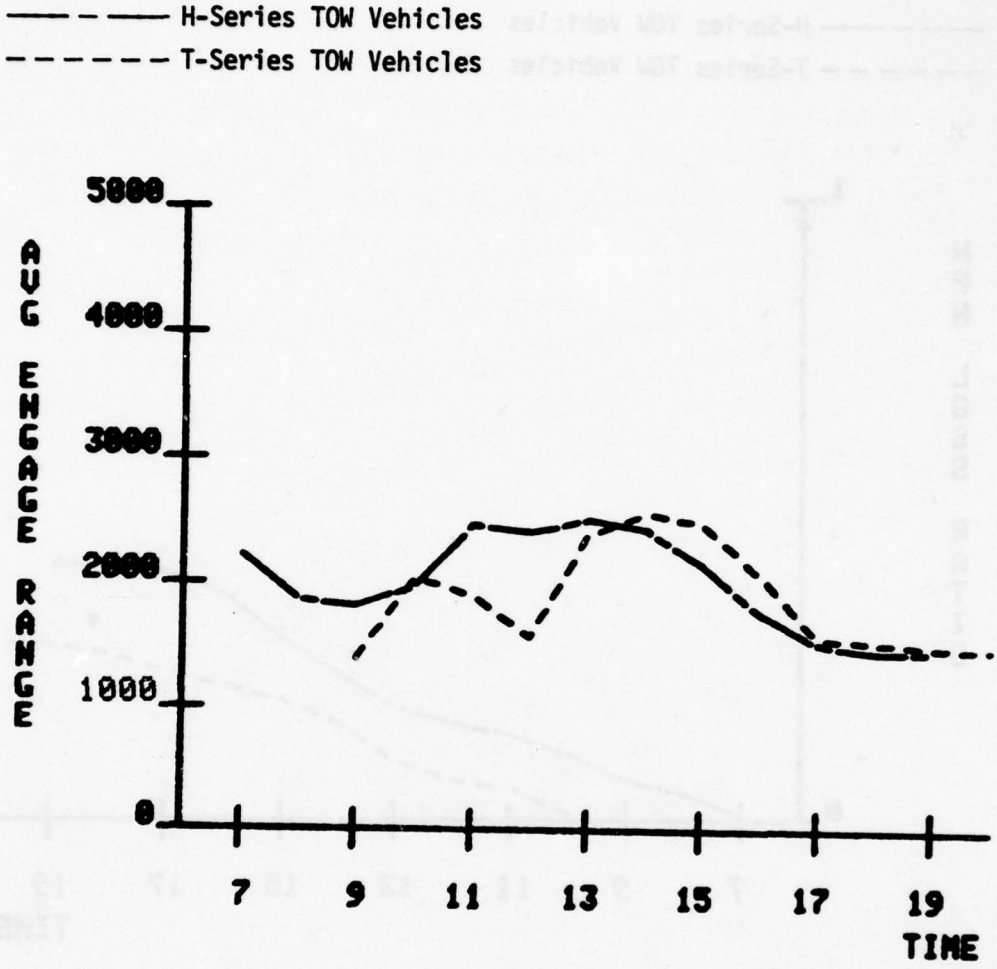

Figure 50. Average engagement ranges for mech organization TOW vehicles in deliberate attack.

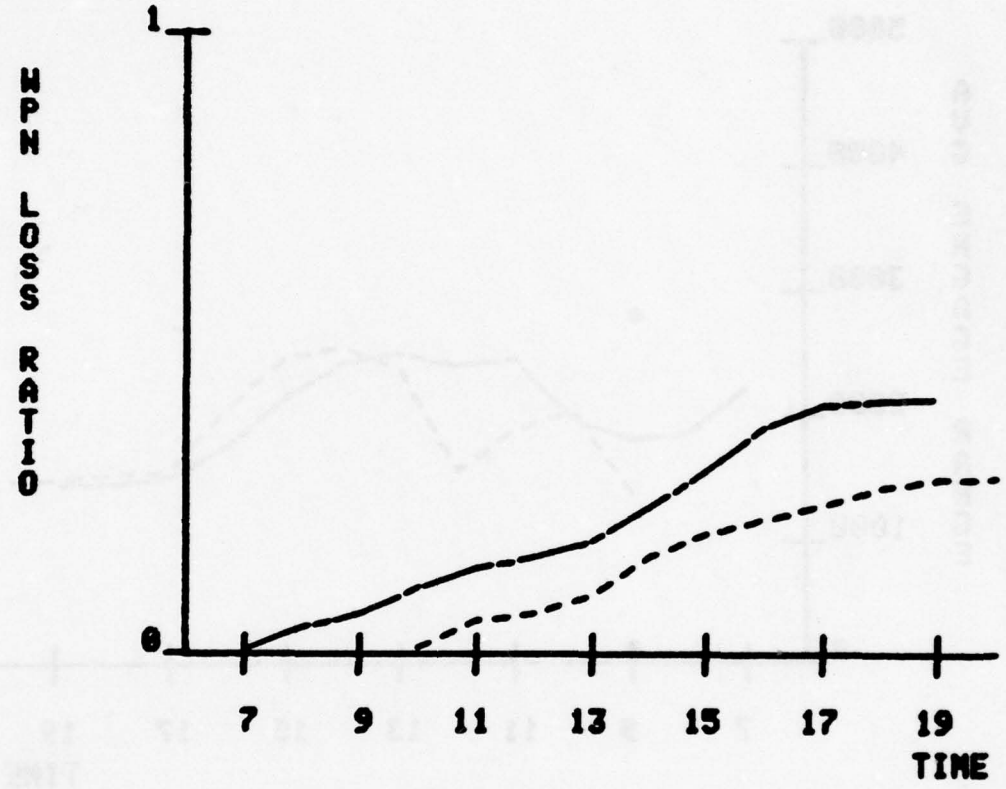

Figure 51. Weapon loss ratios for mech organization TOW vehicles in deliberate attack.

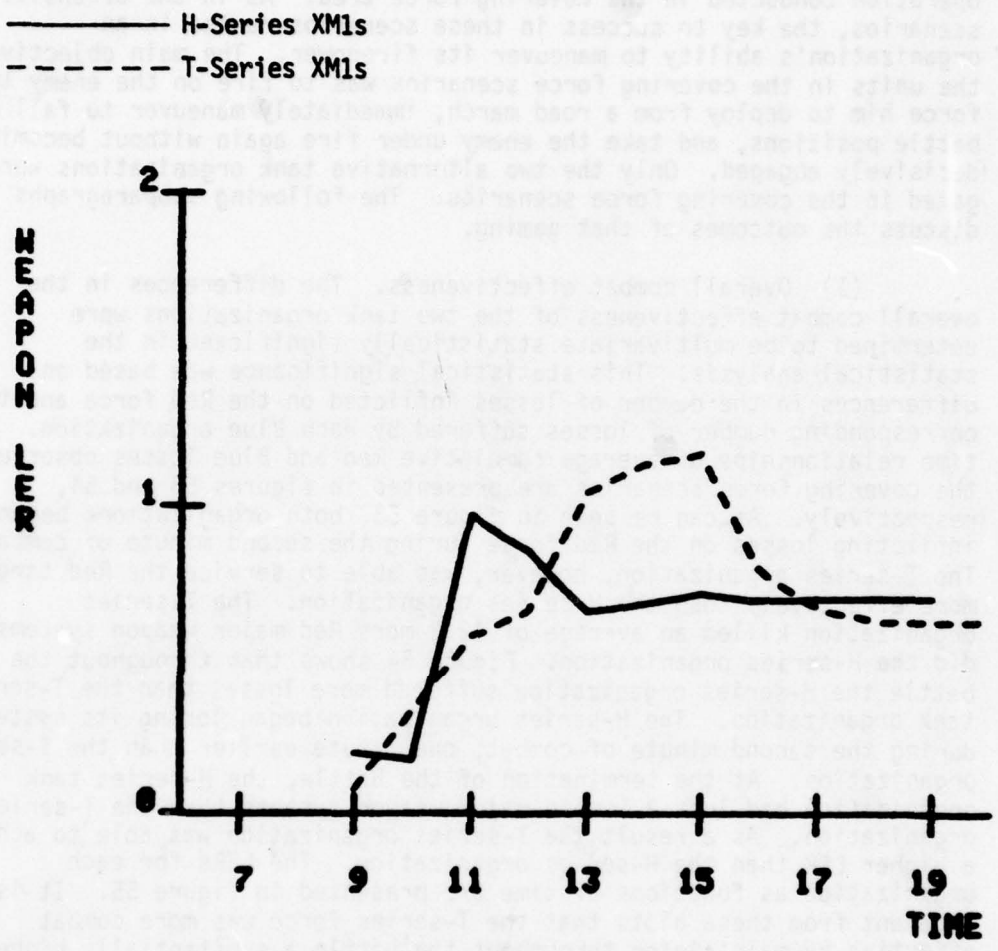

Figure 52. Loss exchange ratios for mech organization XM1s in deliberate attack.

d. Covering Force Scenarios. The last group of scenarios was designed to evaluate the alternative organizations in a delaying operation conducted in the covering force area. As in the offensive scenarios, the key to success in these scenarios rested in an organization's ability to maneuver its firepower. The main objective of the units in the covering force scenarios was to fire on the enemy to force him to deploy from a road march, immediately maneuver to fall back battle positions, and take the enemy under fire again without becoming decisively engaged. Only the two alternative tank organizations were gamed in the covering force scenarios. The following subparagraphs discuss the outcomes of that gaming.

(1) Overall combat effectiveness. The differences in the overall combat effectiveness of the two tank organizations were determined to be multivariate statistically significant in the statistical analysis. This statistical significance was based on differences in the number of losses inflicted on the Red force and the corresponding number of losses suffered by each Blue organization. The time relationships of average cumulative Red and Blue losses observed in the covering force scenarios are presented in figures 53 and 54, respectively. As can be seen in figure 53, both organizations began inflicting losses on the Red force during the second minute of combat. The T-series organization, however, was able to service the Red targets more effectively than the H-series organization. The T-series organization killed an average of 12.2 more Red major weapon systems than did the H-series organization. Figure 54 shows that throughout the battle the H-series organization suffered more losses than the T-series tank organization. The H-series organization began losing its systems during the second minute of combat, one minute earlier than the T-series organization. At the termination of the battle, the H-series tank organization had lost 3.1 more major weapon systems than the T-series organization. As a result the T-series organization was able to achieve a higher LER than the H-series organization. The LERs for each organization as functions of time are presented in figure 55. It is apparent from these plots that the T-series force was more combat effective by maintaining throughout the battle a substantially higher LER. This is also apparent in the SMFRD plots of the two organizations presented in figure 56. The SMFRD plots clearly show a significant difference in combat effectiveness. The T-series organization was able to maneuver its firepower such that during the first 7 minutes of combat, it inflicted heavy losses on the Red force and then began falling back, still managing to kill Red at a rate that kept increasing the SMFRD. The H-series tank organization, on the other hand, was not able to gain much superiority over the Red force. During the first 20 minutes of the battle, the H-series organization did manage to gain a slight advantage over the Red force on two occasions; but at the end of the battle, as indicated by the negative value of the SMFRD, the H-series organization was losing its weapons at a faster rate than the opposing Red force.

(2) Individual weapon system effectiveness. As in the analysis of the offensive scenarios, the measurement of effective firepower percentage (EFP) was first examined in an attempt to explain the large disparity between the combat effectiveness of the two tank organizations. The statistical analysis in table 37 found that both tank organizations maneuvered almost all their XM1s and a large percentage of their TOW weapons into the battle. The T-series organization fought with an average of 96.4 percent (or 24.1) XM1s and 91.8 percent (or 25.7) TOW vehicles, and the H-series organization fought the battle with an average of 98.7 percent (or 31.6) XM1s and 84.8 percent (or 15.3) TOW vehicles. Thus, the T-series tank organization was able to fight the battle with an average of 49.8 major weapon systems, which was 2.9 more systems than the H-series tank organization was able to maneuver into combat. Time plots of the EFPs for the XM1s of each tank organization are presented in figure 57, and the EFPs for the TOW vehicles are presented in figure 58. Figure 57 indicates that the XM1s were involved in the battles in relatively the same proportions during the same times except for brief periods during the fourteenth and twenty-third minutes of the T-series battle. During these time periods small portions of the T-series XM1s were involved in the battle, whereas no H-series XM1s were involved at the corresponding times of their battle. Figure 58 shows similar involvement of the TOW vehicles of each organization occurring during the same time periods in their respective battles. The T-series TOW vehicles appeared to be more active in the early portion of their battle, and the H-series TOWs were more active during the latter stages of the battle. The loss exchange ratios for the XM1s and TOW vehicles of both tank organizations are presented in figures 59 and 60, respectively. Although figures 57 and 58 showed that the XM1s and TOW vehicles were employed similarly, figures 59 and 60 indicate that both of the T-series weapon systems were much more effective than the corresponding H-series weapons.

(a) Weapon system performance. Inspection of tables 37 and 41 from the statistical analysis revealed minor differences in the performance measures between the weapon systems in the two alternative organizations. Table 37 shows that the H-series XM1s accounted for a slightly higher percentage of the Red losses on a per weapon basis than did the T-series XM1s. Table 41 shows the same relationship existing between the H and T-series TOW vehicles. So, on a per weapon basis, the H-series weapon systems seemed to out-perform the T-series weapons. Thus, the reason the T-series weapons were more effective, as was shown in figure 59 and 60, was that they suffered fewer losses. Figures 61 and 62 are cumulative plots of the weapon loss ratios for XM1 and TOW vehicles, respectively. It is evident from both of these figures that the H-series XM1s and TOW vehicles did incur heavier losses. Since the performances of the individual types of weapon systems were virtually the same, the observed difference in Blue losses was attributed to differences in the deployment and/or tactics used during the gaming of the two respective scenarios.

(b) Initial deployment. The initial positions of the T-series tank and H-series tank organizations are presented in figures 63 and 64, respectively. Careful examination of these figures shows, that, excluding the weapon systems that are masked by terrain and beyond the maximum engagement ranges, the initial engagements of the T-series organization are made by two tank platoons (6 XM1s), three TOW sections (6 IFVs), and a scout section (3 CFVs) for a total of 15 major weapon systems. They are encircled in figure 63. The H-series weapon systems involved in the initial engagements are encircled in figure 64. These systems consist of two tank platoons (10 XM1s) and two scout sections (6 CFVs), a total of 16 major weapon systems. Thus, during the initial contact approximately the same number of Blue weapon systems were involved in the battle. The fact that the H-series organization, as shown in figure 54, suffered more average losses during initial contact can, at this point, only be attributed to minor differences in the battle positions occupied by the individual weapon systems of the respective alternative organizations.

(c) Organizational tactics. The tactics used by both organizations were basically the same. A detailed discussion of these tactics is presented in appendix B. Figures 57 and 58 nonetheless indicate that there were some tactical differences. Peaks in the T-series XM1 effective firepower percentage during minute 14, and again during minute 23, as shown in figure 57 indicate that some of the XM1s maneuvered to a subsequent battle position and were again taking the enemy under fire. The absence of these peaks from the H-series EFP curve indicates that the H-series XM1s did not use as many fall-back positions as did the T-series XM1s. Figure 58 shows less difference in the tactical employment of the TOW vehicle between the two organizations. Basically, the TOWs were used throughout the battle except during minutes 10 through 12, when most of the TOW vehicles were moving to their subsequent battle positions.

(3) Summary. In the covering force scenario the T-series tank organization displayed a statistically significant difference and a tactical advantage in combat effectiveness over the H-series tank organization. Examination of the individual weapon system performance parameters found that, on a per weapon basis, the H-series XM1s and TOW vehicles performed slightly better than the T-series weapons. However, the H-series weapon systems incurred heavier losses, which resulted in the T-series XM1s and TOW vehicles being more effective. The differences in survivability appear to result from differences in the initial emplacements of the weapon systems and tactics used in the respective battles.

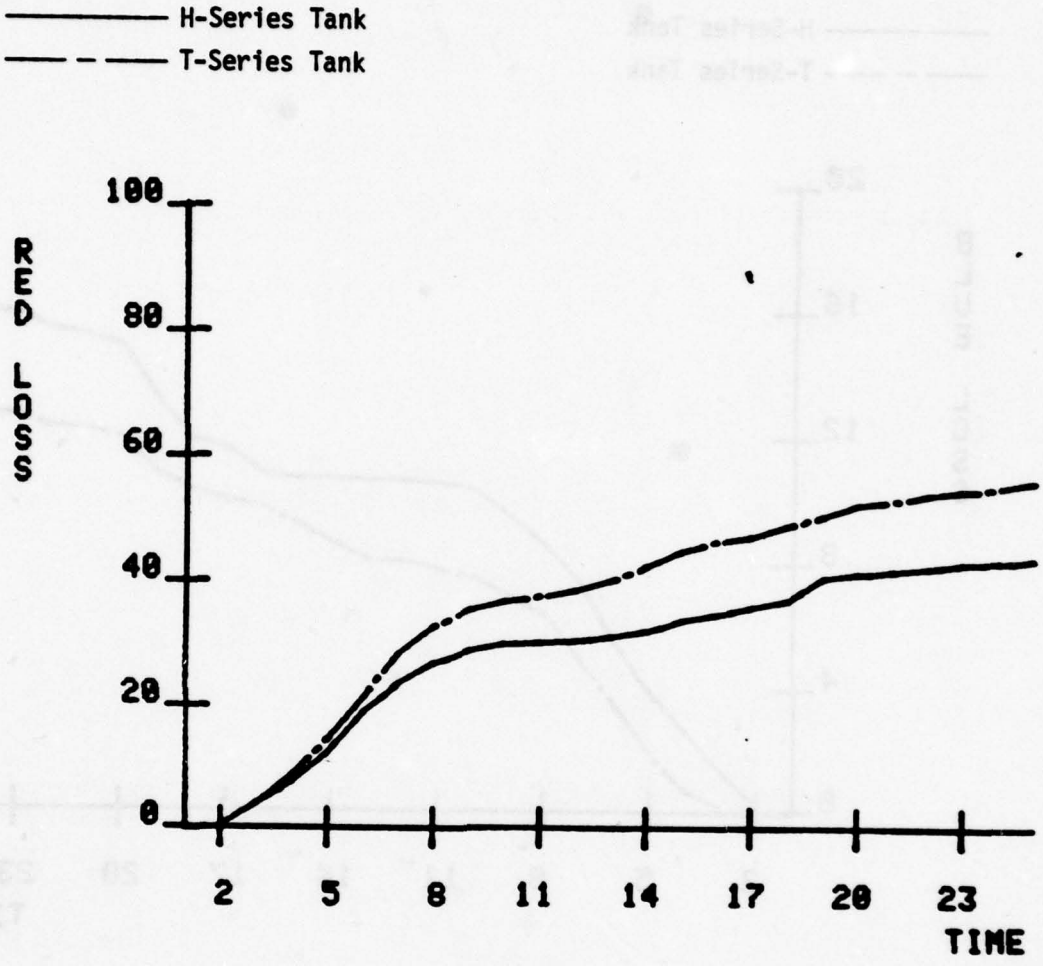

Figure 53. Red losses to tank organizations in covering force action.

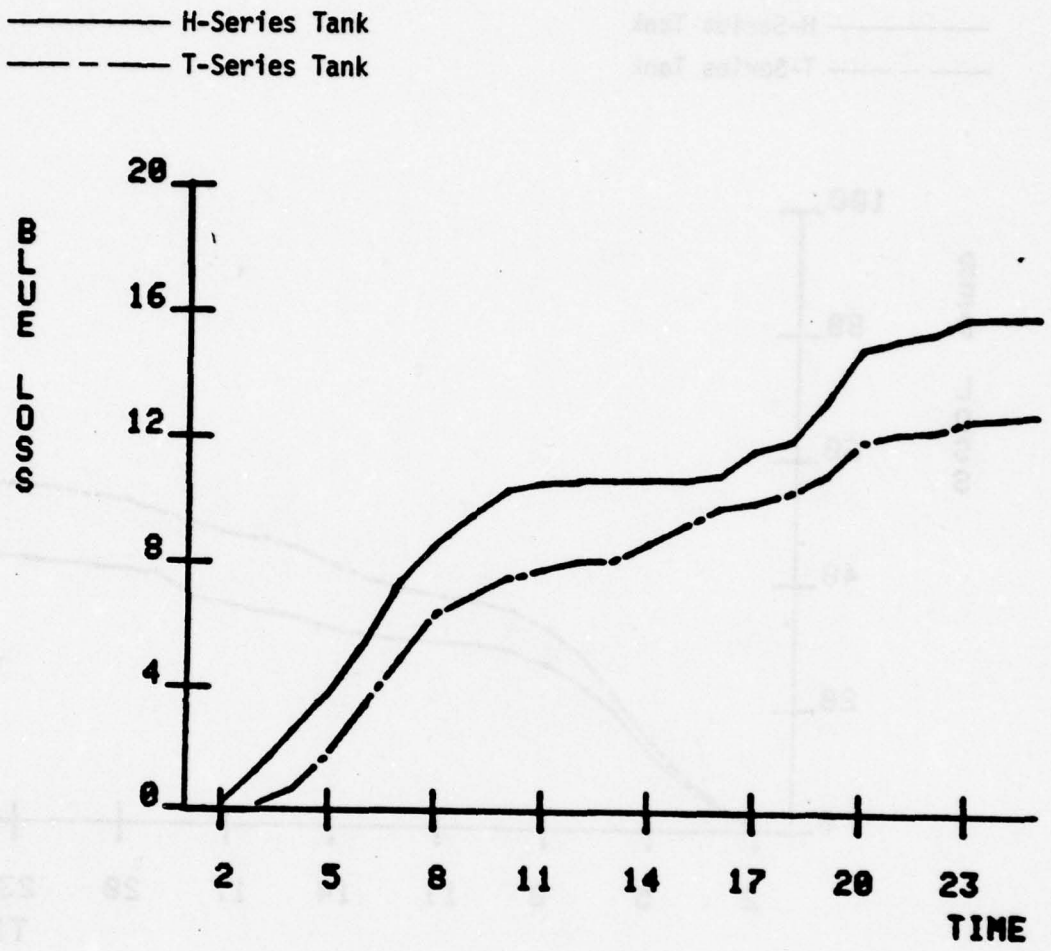

Figure 54. Blue losses incurred by tank organizations in covering force action.

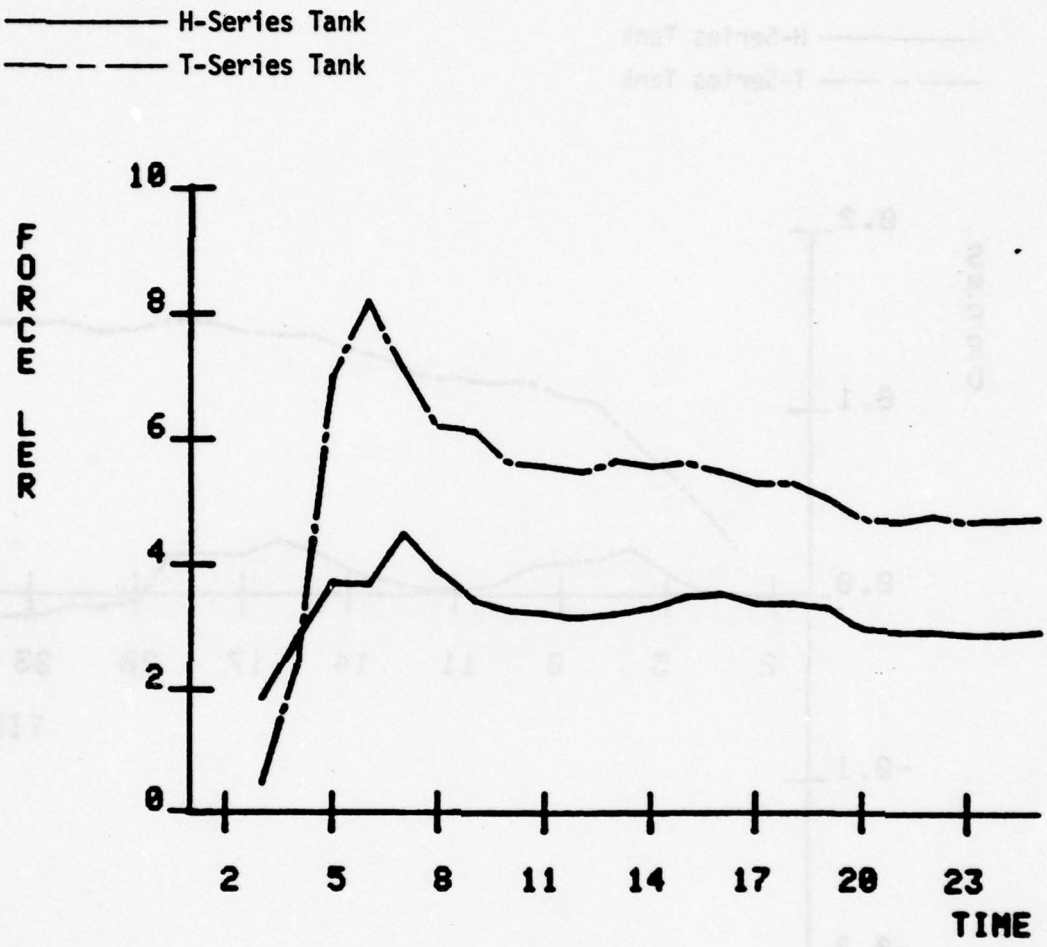

Figure 55. Loss exchange ratios of tank organizations in covering force action.

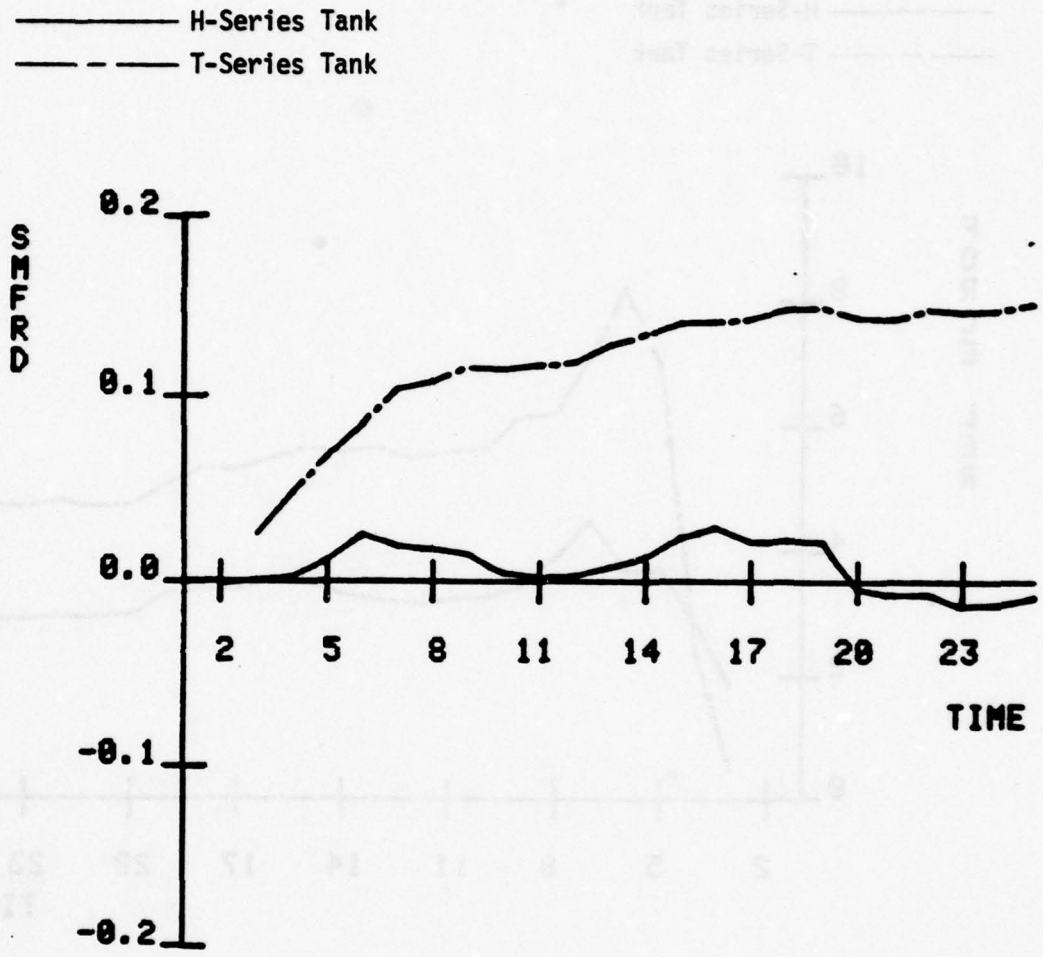

Figure 56. Surviving maneuver force ratio differential of tank organizations in covering force action.

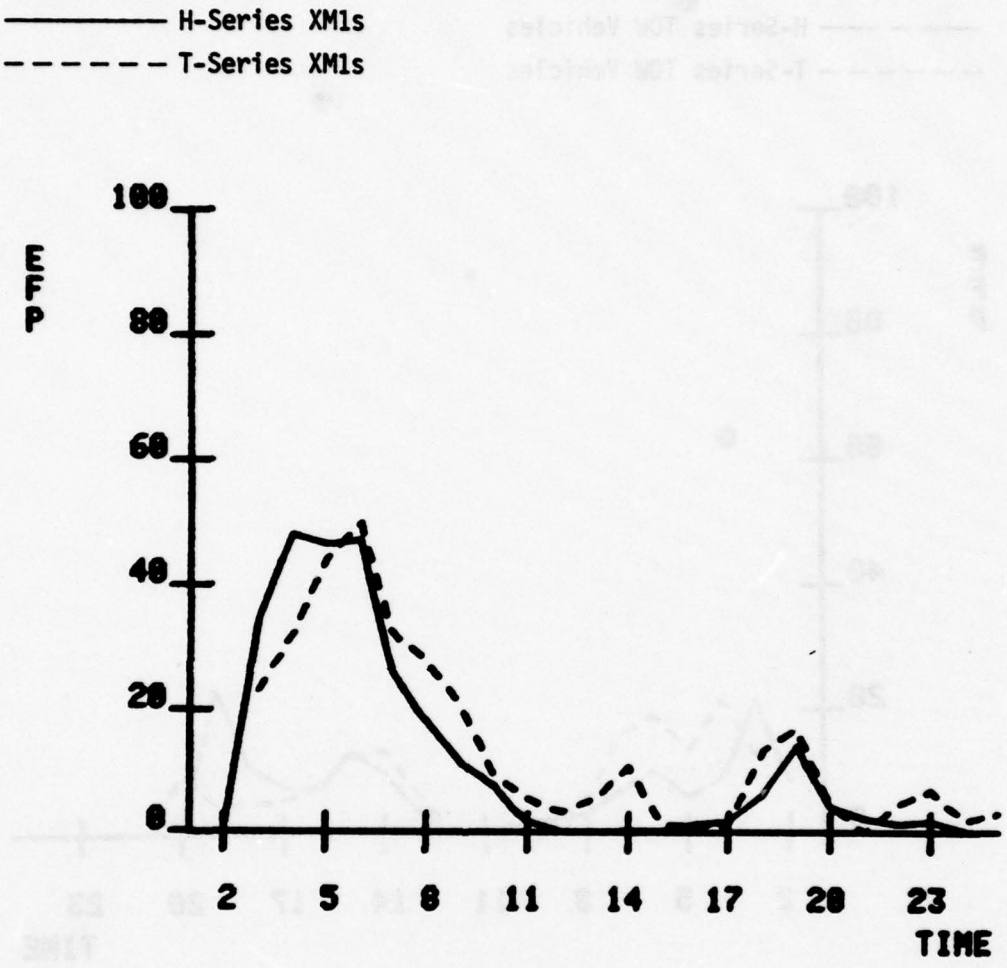

Figure 57. Effective firepower percentage of tank organization XM1s in covering force action.

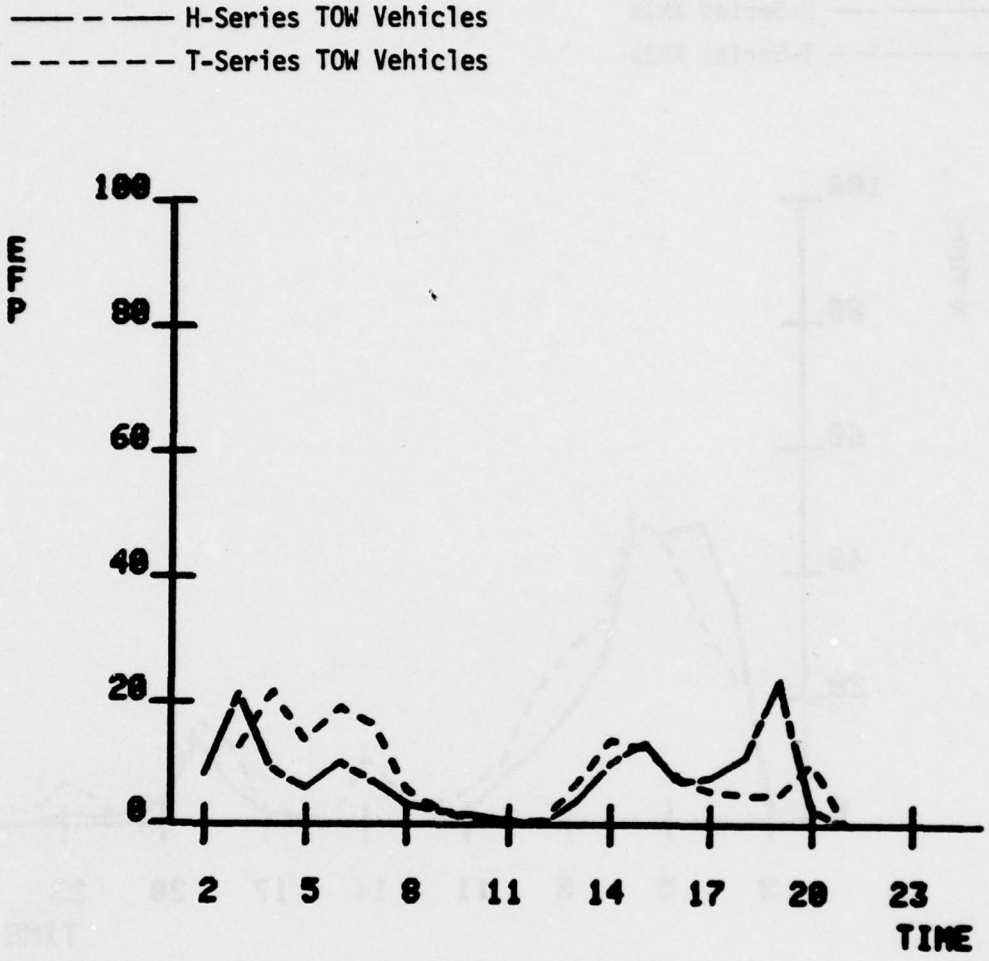

Figure 58. Effective firepower percentage of tank organization TOW vehicle in covering force action.

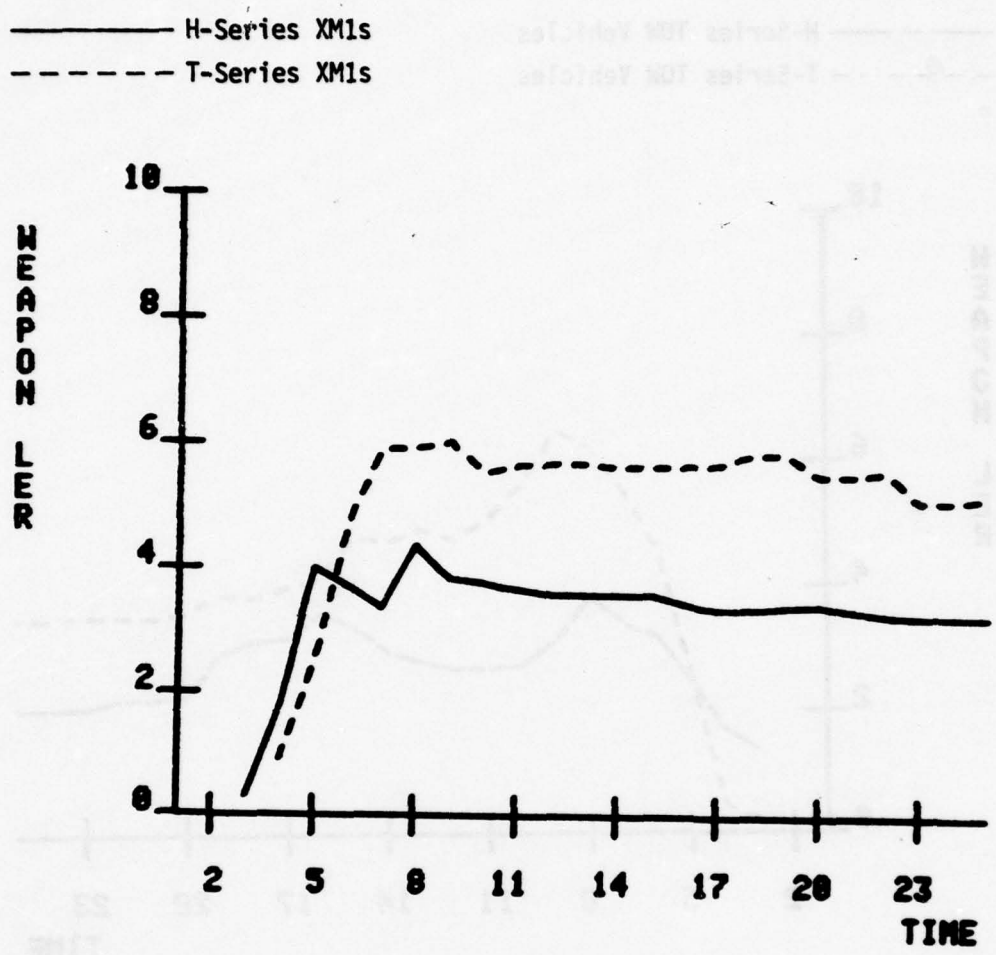

Figure 59. Loss exchange ratios for tank organization XM1 in covering force action.

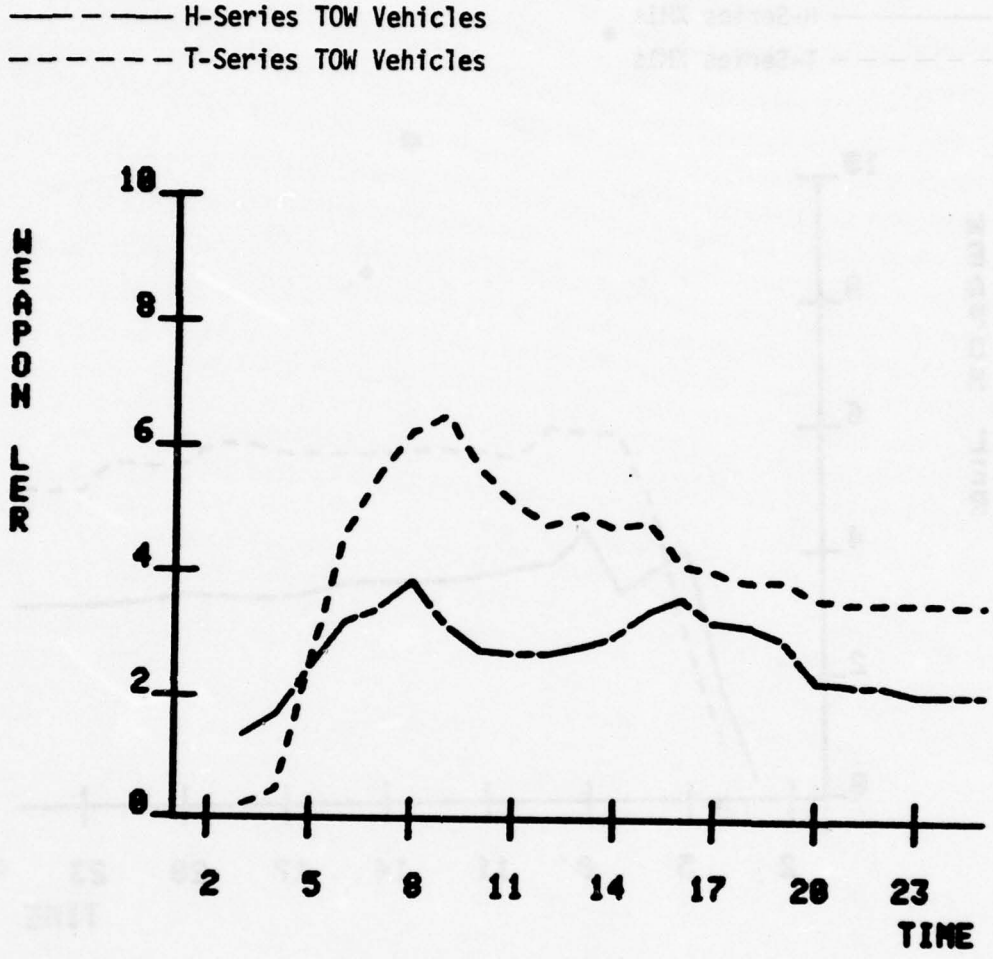

Figure 60. Loss exchange ratios for tank organization TOW vehicles in covering force action.

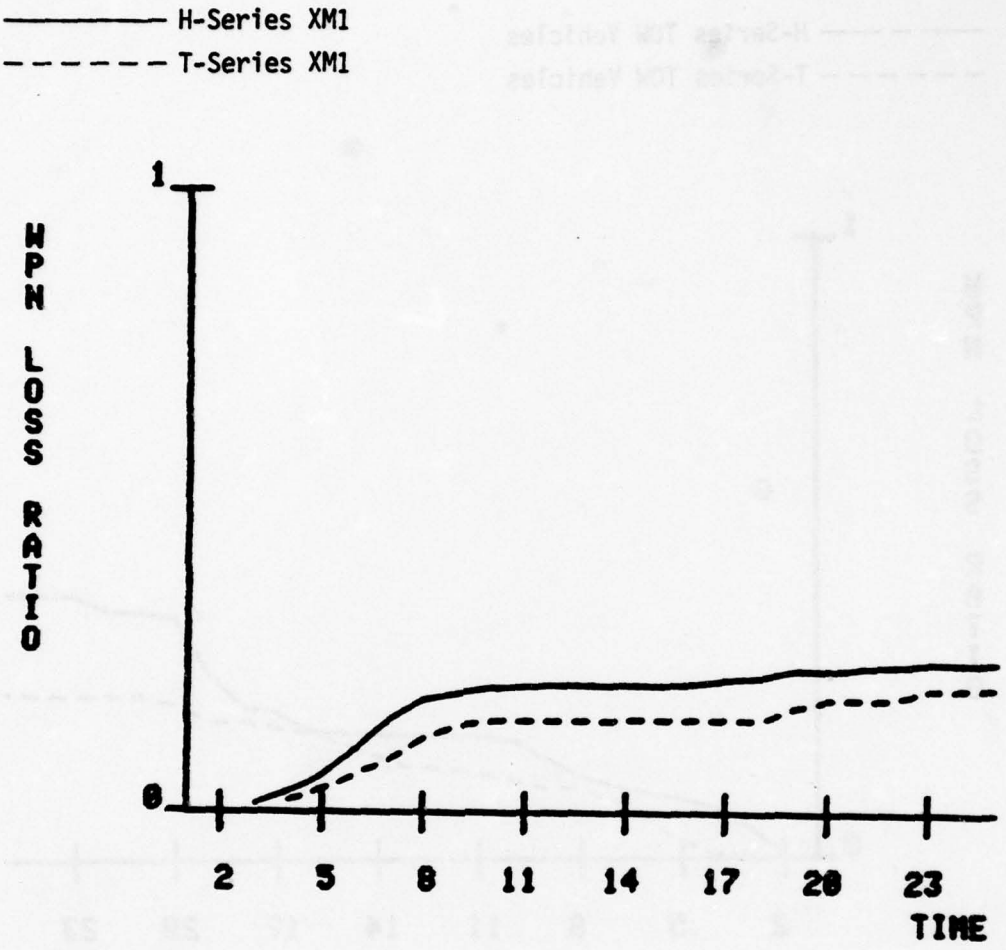

Figure 61. Weapon loss ratio of tank organization XM1s in covering force actions.

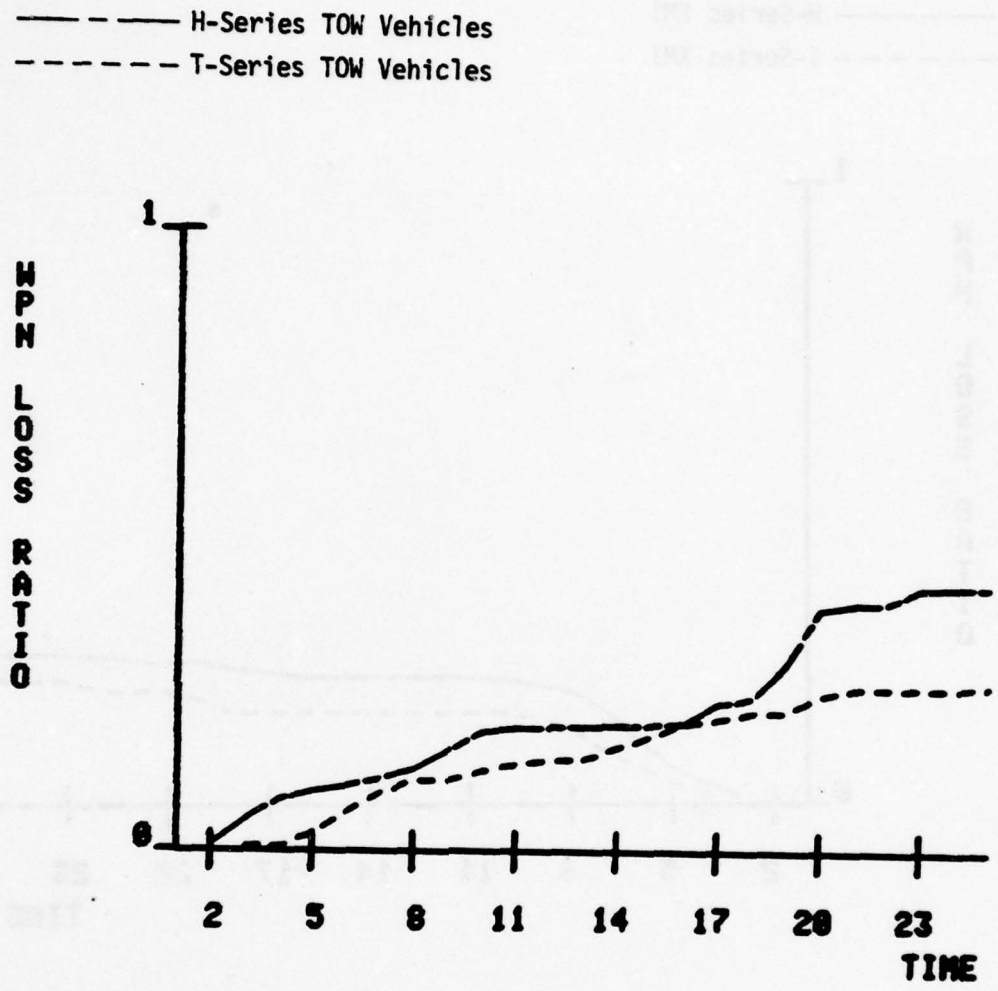

Figure 62. Weapon loss ratios of tank organization TOW vehicles in covering force action.

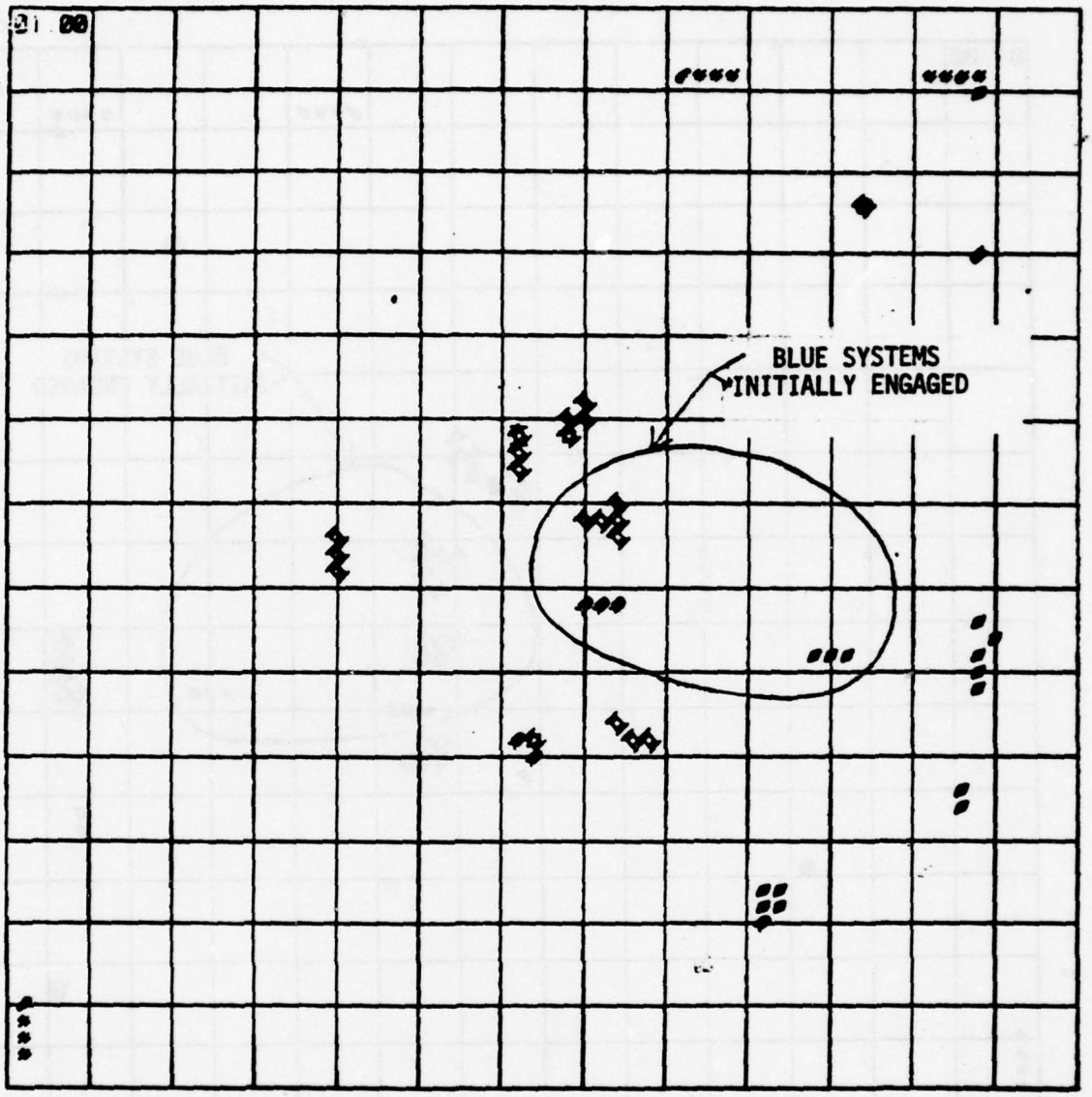

Figure 63. T-series tank organization in initial positions in covering force action.

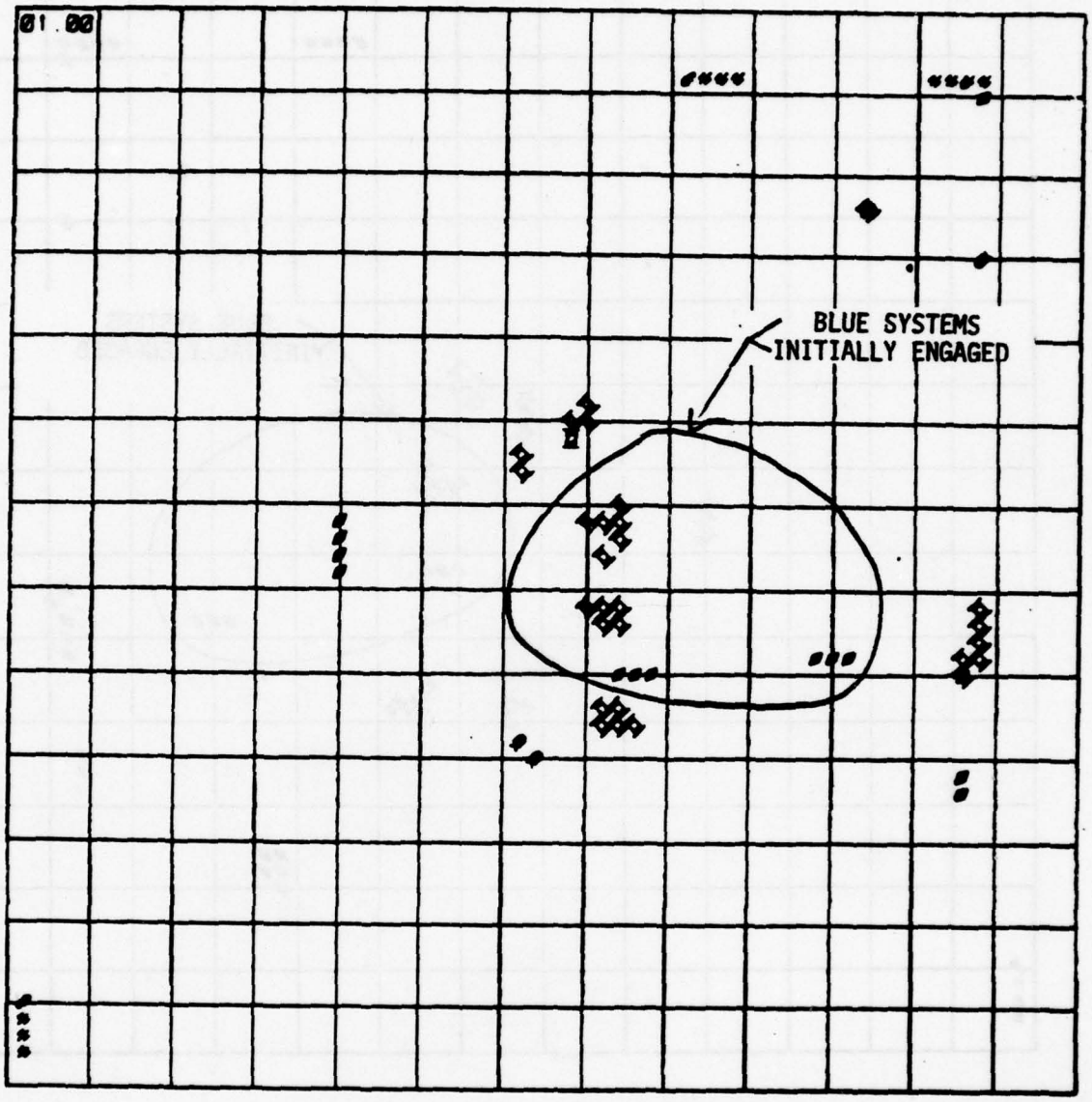

Figure 64. H-series tank organization in initial positions in covering force action.

14. GAMER INSIGHTS AND OBSERVATIONS. This paragraph summarizes the subjective insights and observations developed by gamers during the CARMONETTE gaming. As indicated, some modifications were made to the tactical plan for the purpose of modeling. The scenarios, as modified, were examined and found acceptable by representatives of the Department of Tactics, US Army Command and General Staff College. No attempt has been made to rank these observations and insights in order of importance.

a. Although planned for inclusion in CARMONETTE, minefields and CLGP could not be depicted in the existing model.

b. The representation of poor or limited visibility (smoke) on both defenders and attackers was considered poor and impractical to use in this gaming. Thus, Blue elements in the defense could not withdraw from initial positions, since any movement made them easier to detect and kill.

c. In the Blue defensive scenarios, Red force units lost an inherent advantage by the absence of smoke from their artillery preparations. All Red attacking units could be easily identified during their movement down the open slopes on the eastern side of the river.

d. Movement rates and extended exposure times of the attackers were not reduced by minefields. Craters and bridge destruction were artificially played when required by the situation.

e. Traveling or bounding overwatch tactics were planned for extensive use in the offensive battles. However, the CARMONETTE orders did not have the flexibility to allow "fire and maneuver" tactics to be portrayed properly. Thus, units/weapon systems did not always react to incoming fires as would be expected. Instead, the unit/weapon system continued executing its orders. Since there is no interactive capability in CARMONETTE, the ability to react to a change in the situation; e.g., to maneuver a portion of the force and engage a new threat, cannot be realistically portrayed. For example, supporting maneuver units in overwatch would fire on other targets they detected rather than engage enemy units that were destroying an element the overwatch was supposed to be supporting.

f. In all scenarios, the Red artillery had a very limited effect on the outcome of a battle since few, if any, losses were recorded as a result of Red indirect fire systems. The only effect of Red artillery was suppression.

g. The 6 x 6.3km grid used in the CARMONETTE model required some artificiality in the positioning of attacking forces and, in the case of the Blue defensive and covering force scenarios, made it impossible to emplace local security elements. When either Blue or Red was on the offense the limited area available required the units to be "stacked" one on top of another and then moved one at a time, phasing them into the combat formation and the battle.

h. The Blue artillery adjustment capability and FIST, with its rapid reaction capability, could not be properly played in any scenario. The model indirect fire order string could not be adjusted to fit all contingent situations.

i. In the defense, Blue overwatch support could be conducted by carefully positioned ITVs, although positioning was frequently closer to the FEBA than would normally be considered desirable.

j. In the defense and also the offense, movement rates reflected those developed from the results of the TCATA tests. In an intense 10 to 15-minute battle, using the 16 kph movement rates on improved roads, the time required to identify and then move forces to counter the Red main thrust was not available. Stated simply, the battle was over before the reinforcing elements could bring their weapons to bear. Therefore, reinforcement of a portion of a battalion task force position by less heavily engaged elements was not exercised.

k. CARMONETTE digitized terrain did not necessarily conform to the terrain on the standard military maps. Within each 100-meter grid, the elevation, soil, and vegetation characteristics are taken as an average of each factor as it appears in the grid. Features such as small folds, depressions, and trees were often absent, incorrectly positioned, or less significant in any given grid. In built-up areas and forest, buildings and trees were given an average height. When selecting weapons positions, it was frequently impossible to locate a firing position in a desirable spot since the model data would not accept that position as usable. The model always considered a given position to be in the center of the grid. This frequently resulted in placing a weapons system 25 meters or more away from the location originally selected and required "stacking" one system on top of another.

l. In the defense, the Blue ITV weapons systems, located to the rear of the FEBA, were the only elements to maneuver during the course of a defensive battle. Any weapons system located along the FEBA that attempted to move during the battle was immediately destroyed by Red direct fire. This was partially the result of the inability of the model to play smoke as well as the effect of the open terrain.

m. Those units defending along the FEBA survived longer and fired more effectively and rapidly if left in initial positions.

n. The key factor in a successful defense was to place the heaviest possible fire from the maximum number of available direct fire systems on the forces making the main attack. Highly survivable, rapid fire weapons systems integrated with longer range, slower firing missile systems were needed to engage enemy forces in the highly lethal, target rich environment depicted in the model. In the defense or in a covering force operation, the greatly outnumbered defender must inflict, early on, the maximum number of casualties on the attacker or face annihilation as his losses mount out of all proportion to those losses suffered by the attacker.

o. In all the scenarios that were developed, the T-series task forces had an advantage since the configuration of the three maneuver companies (as opposed to two companies in the H-series) could normally bring more weapons systems to bear against the opposing forces either directly or in a maneuver support role. This flexibility was not present in the two company H-series task forces.

p. In the attack or defense, the need to task organize below company level was frequently highlighted in the scenarios. Mech infantry and armor weapons systems complemented one another; neither was as effective when employed alone. For example, in an attack conducted by a T-series unit, pure infantry or tank companies moving any distance encounter widely varying types of terrain and a wide variety of natural or man-made obstacles. To reduce or destroy an obstacle or an occupied strong point, the need may well exist to dismount infantry or employ tank fires to reduce enemy resistance. In the T-series, moving on three axes of advance, frequently separated by 1 kilometer or more and masked by terrain features, the mutual support provided by a company level combined arms team would be impossible to attain. The combination of infantry and tank units down to and including attachment at platoon level must be continued if they are to achieve the necessary flexibility not possible in "pure" company units.

15. FINDINGS.

a. Although the observed differences in the performances of the individual weapon systems when grouped as either a T-series or an H-series organization were not consistently the same over all the scenarios, a few general trends were observed. These trends were discussed in the previous paragraphs and are summarized below.

(1) The company team concept should be incorporated into the T-series doctrine. In the defense, this concept provided the gamer the flexibility to employ the most effective mix of rapid fire and long range weapon systems as dictated by the situation. In the offense, a variety of man-made and natural obstacles may need to be reduced or destroyed, thus requiring infantry to dismount. Occasions also frequently arise that require the rapid fire characteristics of tanks to reduce enemy fires. Thus, the company team concept is best suited to cope with the varieties of situations encountered on the battlefield.

(2) The scenarios in which the Blue force had to effectively maneuver its weapon systems found that the T-series organizations were consistently able to maneuver more of their weapon systems into the battles. Thus, the T-series consistently fought the battles with more weapon systems than the H-series organizations. This difference in the performance of the weapon systems is attributed to the fact that the T-series weapon systems were organized into three companies whereas the H-series weapons were organized into only two companies. This difference in configuration provided the T-series organization with an additional axis of advance in the offensive scenarios and better mutual support during the fall back operations of the covering force actions.

(3) The configuration of three companies also gave an advantage to the T-series organizations in the position defense scenarios. The three companies could be placed where they could provide mutual covering support. Elements of the two companies under the H-series concept of organization were emplaced too far apart to provide effective support fires.

b. The T-series organizations were found to be more combat effective than the H-series organizations in four of the five comparisons. In two of these comparisons, those for the offensive scenarios, the T-series organizations were shown to be statistically more combat effective; however, for all practical purposes, the combat effectiveness of the alternative organizations was the same. In the remaining comparisons, which found both a statistical and a practical difference in combat effectiveness, the T-series organizations were found to be more effective in two of the comparisons and the H-series organization was found to be more effective in one comparison. Thus, although there were advantages associated with both organizational concepts, neither seemed to display a distinct advantage over the other.

16. REFERENCES.

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2. USACACDA TP 2-78, Analysis of Mobility Data from the Division Restructuring Evaluation Battalion Test, April 1978.

3. USAEWES, Terrain Description, Cover and Concealment Calculations and Vehicle Speed Predictions for AMORES, Mobility and Environmental Systems Laboratory, USA Engineer Waterways Experimentation Station, June 1976.

4. Anderson, T.W., An Introduction to Multivariate Statistical Analysis, John Wiley & Sons, Inc., 1958.

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APPENDIX A

DEVELOPMENT OF THE CARMONETTE MOBILITY DATA BASE

APPENDIX A

DEVELOPMENT OF THE CARMONETTE MOBILITY DATA BASE

A-1. TCATA MOBILITY DATA. During the DRE Battalion Test trials conducted at TCATA, data on the positions of tanks (M60A1s) and TOW-carrying vehicles (M113s) were recorded 10 times a second. These data were analyzed (reference 2) at CACDA in an effort to determine the tactical mobility of these vehicles both on and off roads as a function of mission, slope class, and vegetation/trafficability.

A-2. STRUCTURE OF CARMONETTE MOBILITY DATA. The mobility data for CARMONETTE ground units are organized by mobility class, road condition, slope of terrain, and trafficability. The extent of these data is subject to the following limitations:

- Five mobility classes
- Two road conditions (on and off roads)
- Five slope classes
- Three trafficabilities (good, average, poor).

Thus, up to 150 separate data entries may be used to define the maximum movement rates for ground personnel and vehicles within any CARMONETTE run.

A-3. CONSTRUCTION OF CARMONETTE MOBILITY DATA. The Blue vehicles gamed for DRE were the XM1, IFV/CFV, and ITV/M113. Since the Battalion Test was conducted with M60A1s and M113s, the CARMONETTE tactical mobility data had to be extrapolated from the test results. The following steps were used in this exercise.

a. A separate set of data indicating the maximum operational (i.e., ride limiting) speeds of the XM1, IFV/CFV type vehicles, M60A1, and M113 was obtained from TRASANA. These speeds are termed "ride limiting" speeds because they are based on the speed at which the driver of a vehicle is subjected to 6 watts of energy (the maximum at which an average driver can sustain operation of a vehicle). For both cross-country and road movement, the ride limiting speeds were provided as functions of slope and three types of trafficability.

b. The tactical mobility data for the XM1 were extrapolated using the following algorithm. A ratio, r_{M60A1}, was computed as:

where:

i = the index on slope class (i = 1,...5).

j = the index on road condition (j = 1,2).

k = the index on trafficability (k = 1,2,3).

$\bar{X}_{ijk}$= the average observed speed of the M60A1 from the analysis of the DRE Battalion Field Test results (reference 2) for the ijk-th combination.

y_{ijk}= the ride limiting speed for the M60A1 for the ijk-th combination.

n_{ijk}= the number of observations for the ijk-th combination.

The ride limiting speeds of the XM1 were then multiplied by this ratio to produce the XM1 tactical mobility entries for CARMONETTE.

c. Since the IFV/CFVs are considered companion vehicles to the XM1, they were moved at the same tactical mobility rates as the XM1. In most cases, the tactical mobility speeds for the XM1s were one-third to one-half the ride limiting speeds of the ITV/M113. For this reason it was considered reasonable that the ITVs and M113s could also move at the same tactical mobility rates extrapolated for the XM1s. So, for the purposes of the DRE battalion gaming, the XM1, IFV/CFV, and ITV/M113 were all placed into a single mobility class.

A-4. RESULTING MOBILITY RATES. Tables A-4-1 through A-4-8 display the resulting mobility rates for the Blue offensive and defensive scenarios. A simplifying assumption was that the mobility rates for corresponding uphill and downhill slope classes were identical.

A-5. RED MOVEMENT RATES. Because the force opposing the Blue test organizations did not strictly employ Red tactics for training reasons, extrapolation of Red tactical mobility rate was deemed inappropriate. Based on a sensitivity analysis and Red doctrine, the Red vehicles were moved at 5 m/sec (18 km/hr) except where terrain precluded this speed.

Table A-1. T-series tank offensive movement rates (meters/sec).

Slope	Cross-Country Trafficability			On Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	4.358	3.341	2.231	5.800	5.424	5.033
Moderate Uphill/Downhill	2.310	2.221	1.728	3.010	2.657	2.229
Steep Uphill/Downhill	.997	.952	.723	1.135	1.099	.967

Table A-4-2. H-series tank offensive movement rates (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	4.767	3.655	2.440	6.345	5.933	5.505
Moderate Uphill/Downhill	2.527	2.430	1.890	3.292	2.906	2.222
Steep Uphill/Downhill	1.090	1.041	.791	1.242	1.202	1.058

Table A-4-3. T-series mech offensive movement rate (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	4.886	3.746	2.501	6.503	6.435	5.643
Moderate Uphill/Downhill	2.590	2.490	1.937	3.374	2.976	2.455
Steep Uphill/Downhill	1.117	1.068	.810	1.273	1.232	1.084

Table A-4-4. H-series mech offensive movement rates (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	5.414	4.151	2.771	7.206	6.738	6.253
Moderate Uphill/Downhill	2.870	2.759	2.146	3.739	3.301	2.770
Steep Uphill/Downhill	1.238	1.183	.898	1.410	1.365	1.201

Table A-4-5. T-series tank defensive mobility rates (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	5.018	3.848	2.569	6.679	6.245	5.795
Moderate Uphill/Downhill	2.660	2.557	1.989	3.466	3.059	2.339
Steep Uphill/Downhill	1.148	1.096	.832	1.307	1.265	1.113

Table A-4-6. H-series tank defensive mobility rates (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	5.037	3.863	2.579	6.705	6.270	5.818
Moderate Uphill/Downhill	2.670	2.567	1.997	3.479	3.071	2.577
Steep Uphill/Downhill	1.152	1.101	.835	1.312	1.270	1.118

Table A-4-7. T-series mech defensive mobility rates (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	5.322	4.080	2.724	7.083	6.623	6.146
Moderate Uphill/Downhill	2.821	2.712	2.110	3.675	3.244	2.722
Steep Uphill/Downhill	1.217	1.163	.883	1.386	1.342	1.181

Table A-4-8. H-series mech defensive mobility rates (meters/sec).

Slope	Cross-Country Trafficability			On-Road Trafficability		
	Good	Average	Poor	Good	Average	Poor
Negligible	5.454	4.182	2.792	7.259	6.788	6.298
Moderate Uphill/Downhill	2.891	2.779	2.162	3.767	3.325	2.790
Steep Uphill/Downhill	1.247	1.192	.904	1.421	1.375	1.210

APPENDIX B

DESCRIPTION OF SCENARIOS

B-1. INTRODUCTION.

a. General. The development of offensive and defensive scenarios for battalion sized mechanized infantry and armor task forces (TF) (1985 timeframe) required visualization of the course of the entire battle from initial contact through to extensive destruction of either the Blue or Red force or both forces. Two 6 x 6.3 km areas were selected for the sites of the battles. Area 1, located between the towns of NIEDERJOSSA and NIEDERAULA on the FULDA RIVER, was used for the defensive scenario. Area 2, located east of Area 1, was centered on the towns of ARZELL and EITERFELD and was the site for the offensive and covering force battles.

b. Terrain Analysis.

(1) Area 1 (Defense, Blue forces). A detailed analysis of the terrain was made over the 6 x 6.3 km grid selected for the conduct of the defense in Area 1 as shown in figure B-1. A summary of the analysis appears below.

(a) The open area between the towns of NIEDERAULA on the north and NIEDERJOSSA on the south is approximately 3 1/2 km wide. This area will support a regimental attack. An avenue of approach east of the FULDA RIVER is controlled by the west bank hill complex, lightly covered with scattered trees, Hills 337 (NB 3926), 354 (NB 4036), 352 (NB 4027), and 333 (NB 4127). The treeline on the east bank of the FULDA runs generally along the crest of the hill complex from Hills 398 (NB 4223), 328 (NB 4325), and 330 (NB 4421). The eastern approaches down to the FULDA RIVER are sparsely vegetated with broken gradual slopes except in the center third of the area, where steep slopes make vehicular movement difficult. The FULDA RIVER is not considered a significant barrier to a motorized rifle regiment.

(b) Within the regimental avenue of approach three separate avenues were identified. Those identified are shown in figure B-1 and discussed below.

1. Avenue of Approach A (northern): from NB 427247 to NB 432274. This approach includes both bridge and crossing sites. It is about 800 m wide and will support a battalion attack.

2. Avenue of Approach B (center): from NB 425253 to NB 426266. It contains no crossing sites or bridges. It is about 1 km wide and will support a battalion attack.

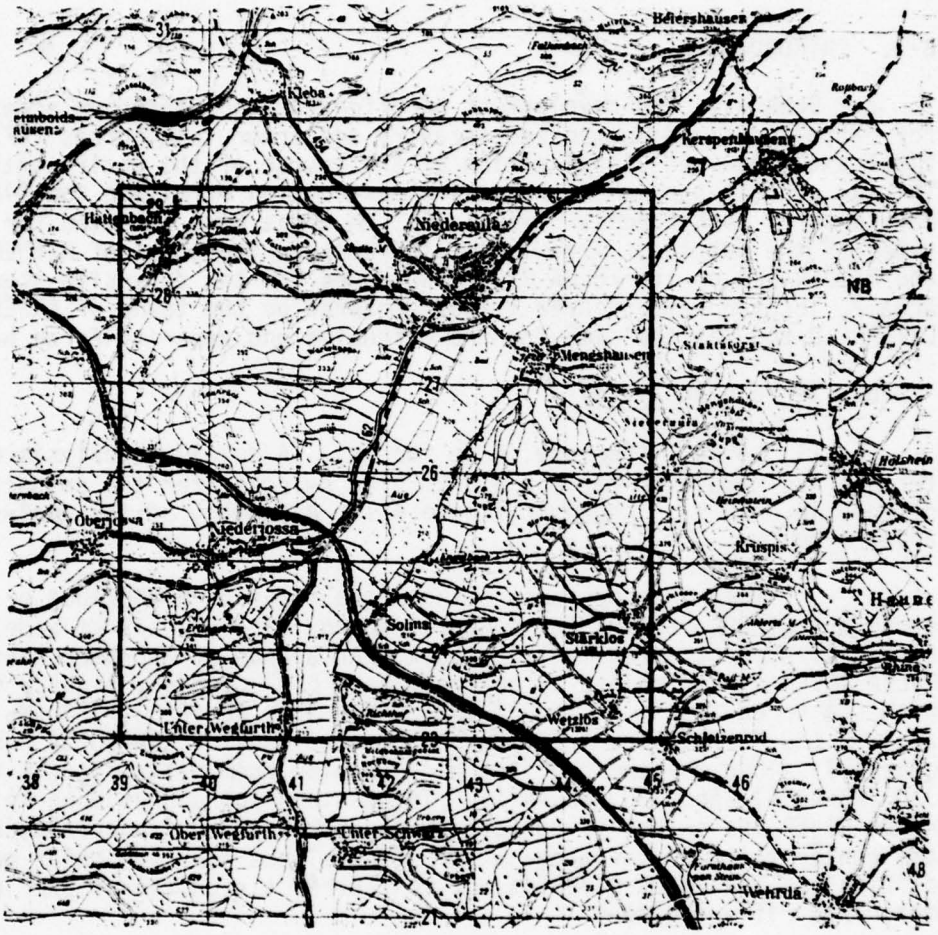


Figure B-1. Terrain area 1.

3. Avenue of Approach C (south): from NB 414240 to NB 422253. This approach includes an autobahn crossing, a secondary bridge, and crossing sites over the FULDA RIVER. It is about 1 1/2 km wide and will support an attack by a reinforced battalion, although approaches down to the FULDA RIVER are restrictive.

(c) Although the FULDA RIVER is not considered a significant barrier, it does qualify as "disruptive terrain." Mean water depth is over 1.8 m, while the river width between NIEDERJOSSA and NIEDERAULA is between 18 and 20 m. The river bottom is rocky or gravel with a few sand deposits. There are two fording sites (NB 421251 and NB 423275) just north ENGELBACH (NB 4224). Each location has a mean water depth of 1 m, and each is about 16 m wide with good approach roads.

(d) The towns of NIEDERAULA (NB 4228), MENGSHAUSEN (NB 4327), NIEDERJOSSA (NB 4025), and SOLMS (NB 4124) serve to disrupt movement of attacking forces.

(e) Likely enemy objectives were identified as Hill 334 (NB 3726), BRIETENBACH (NB 3625), and Hill 300 (NB 373239). It should be noted these were not included in the 6 x 6.3 km area in which all Area 1 battles were fought.

(f) The most likely avenue of approach for the enemy main effort is Avenue C since access routes to, and maneuver space in the vicinity of, the river are adequate for a battalion (+) force. After crossing the river, NIEDERJOSSA, OBERJOSSA, and BREITENBACH constitute obstacles to maneuver. The northern approach, Avenue A, could well accommodate a supporting attack of the regiment. During an attack, units from both Avenues A and C would probably "spill out" into Avenue B.

(2) Area 2 (Offense and Covering Force Operations, Blue Forces). The terrain in Area 2 is depicted in figure B-2 and could be generally described as rolling, lightly forested, and well adapted for movement of armored vehicles.

(a) The major avenue of approach encompasses the road networks leading into the area from the northeast along the axis MENGERS (NB 5527), EITERFELD (NB 5623), STEINBACH (NB 5220), and BETZENROD (NB 5420) and on toward the southwest. This approach varies in width from 1 to 4 1/2 kms and can support an attack by a regimental sized force.

(b) In the north, between BUCHENAU (NB 5425) and ARZELL (NB 5524), vehicular movement is restricted by the steep slopes of the ridgelines along either side of Hwy 27. These, and the approach to ARZELL and EITERFELD, are dominated by the heavily forested Hill 400 (NB 5324).

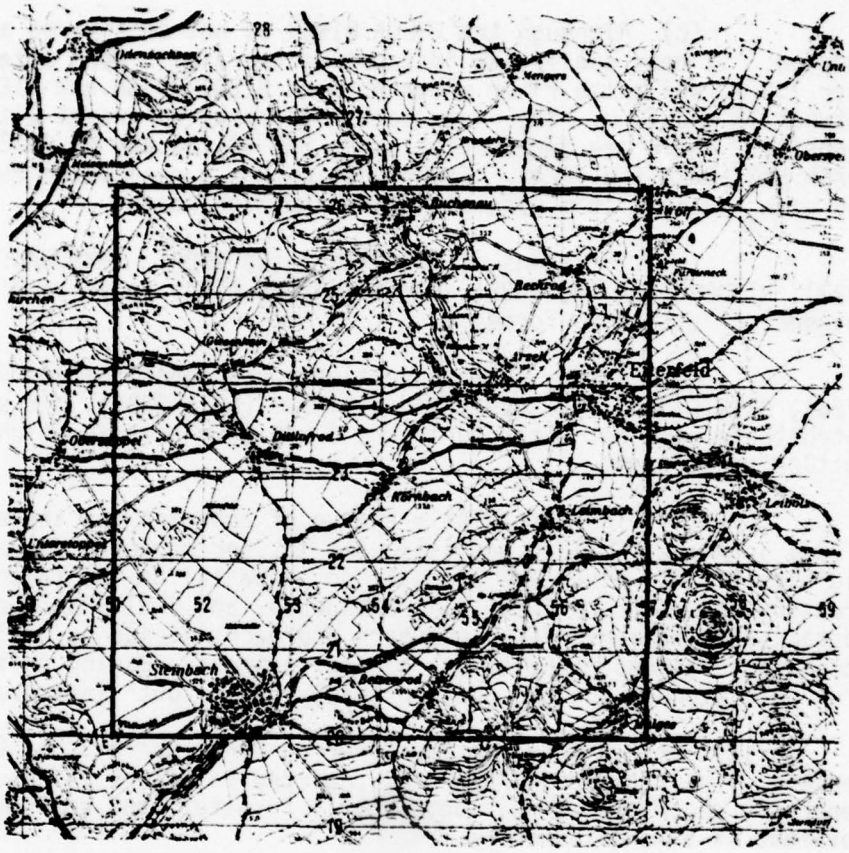


Figure B-2. Terrain area 2.

(c) In the south, the avenue of approach is dominated by the high ground in the vicinity of Hill 429 (NB 5519). This hill mass controls the road network from the east and north.

(d) The towns of ARZELL and EITERFELD serve to restrict and disrupt movement of attacking forces. The avenue of approach at this point narrows to less than 1 km.

(e) All streams in the area are fordable, with none considered a significant barrier. Roads and trails throughout the area are in good condition and aid movement of both Blue and Red forces.

(f) Weather has been dry with visibility good to excellent during daylight hours.

c. Organizations.

(1) Blue force battalion task force organizations are in the main body of the report at figures 1 through 4.

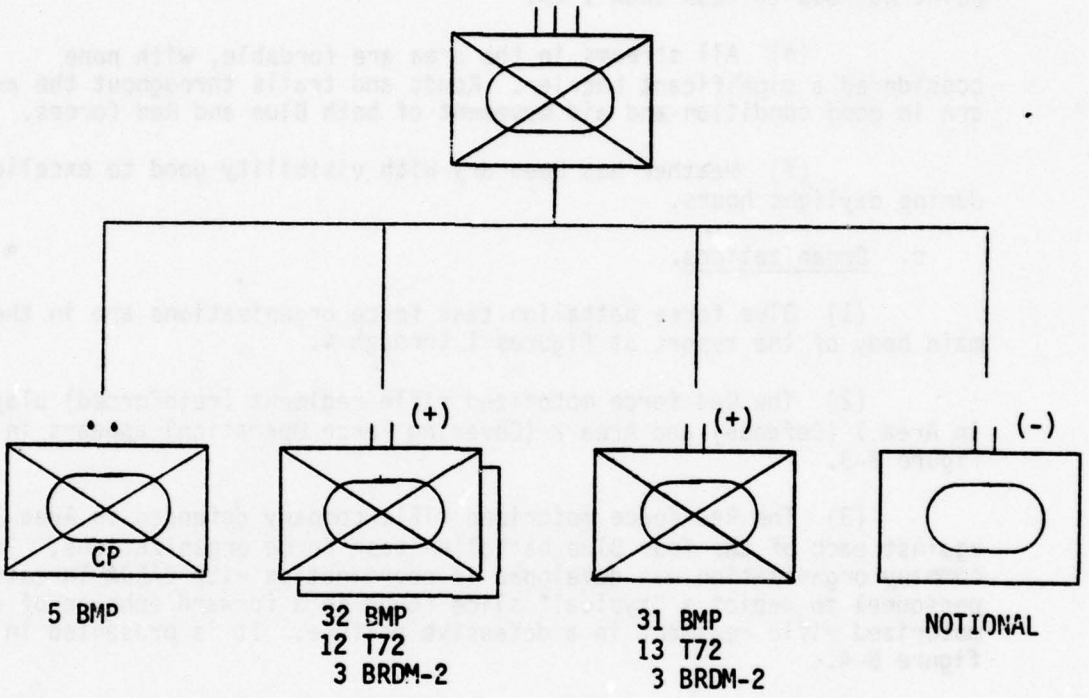
(2) The Red force motorized rifle regiment (reinforced) played in Area 1 (Defense) and Area 2 (Covering Force Operation) appears in figure B-3.

(3) The Red force motorized rifle company defended in Area 2 against each of the four Blue battalion task force organizations. This company organization was developed in coordination with CACDA Threats personnel to depict a "typical" slice found in a forward echelon of a motorized rifle regiment in a defensive posture. It is presented in figure B-4.

d. General Situation, Area 1 and Covering Force Operation, Defense and Offense.

(1) Relations between NATO and the Communist powers have been steadily deteriorating. The political consultive body of the Warsaw Pact Treaty Organization met in a closed session on 10 June 1985 and agreed that military action against NATO should be initiated. This decision was ratified at the highest political level by each participating Warsaw Pact nation.

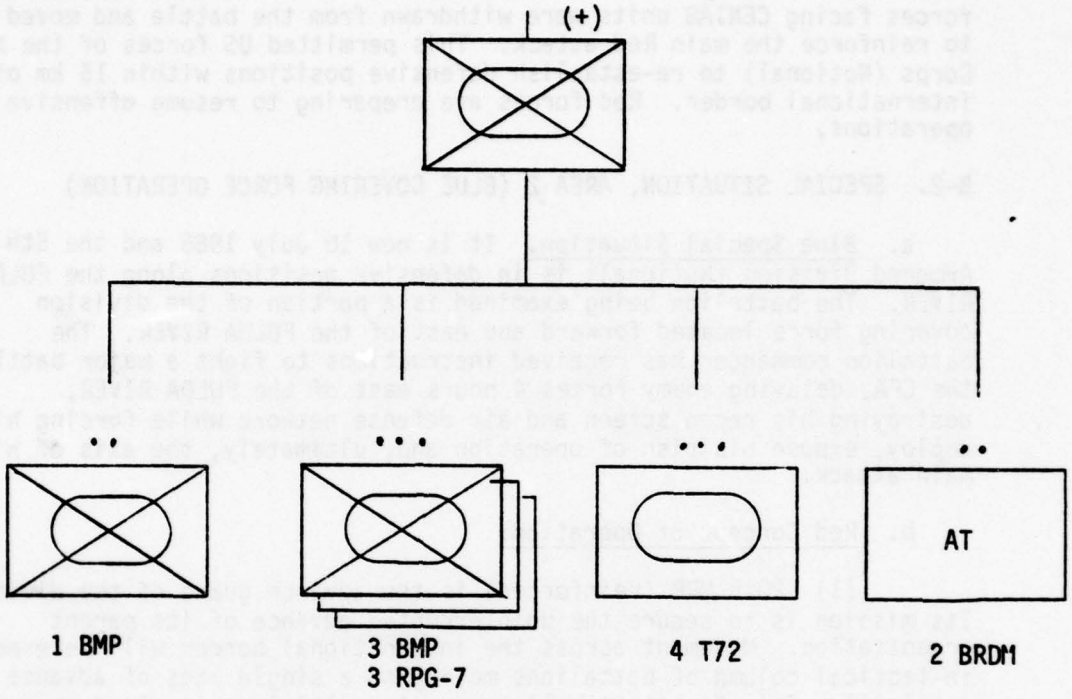
(2) On 14 June 1985 USSR/Warsaw Pact forces launched a nonnuclear attack against NATO. The initial phase of the attack has been aimed at destroying the Allied defensive systems before adequate reinforcement can arrive from Great Britian and CONUS.



TOTALS

100 BMP
37 T72
9 BRDM-2

Figure B-3. Red aggressor force.



TOTALS

10 BMP
4 T72
2 BRDM-2

Figure B-4. Red defender force.

(3) NATO forces have offered much stronger resistance than had been anticipated by the Warsaw Pact, and the attack in the North German Plain was halted by the determined resistance of the NATO forces. Red forces facing CENTAG units were withdrawn from the battle and moved north to reinforce the main Red attack. This permitted US forces of the X Corps (Notional) to re-establish defensive positions within 15 km of the international border. Red forces are preparing to resume offensive operations.

B-2. SPECIAL SITUATION, AREA 2 (BLUE COVERING FORCE OPERATION)

a. Blue Special Situation. It is now 10 July 1985 and the 5th Armored Division (Notional) is in defensive positions along the FULDA RIVER. The battalion being examined is a portion of the division covering force located forward and east of the FULDA RIVER. The battalion commander has received instructions to fight a major battle in the CFA, delaying enemy forces 4 hours east of the FULDA RIVER, destroying his recon screen and air defense network while forcing him to deploy, expose his plan of operation and, ultimately, the axis of his main attack.

b. Red Concept of Operation.

(1) 20th MRR (reinforced) is the advance guard of the division. Its mission is to secure the uninterrupted advance of its parent organization. Movement across the international border will be executed in tactical column of battalions moving on a single axes of advance initially. This formation will expand to multiple axis of advance where terrain and situation dictate. Axis of advance after crossing the international border will be westward, then southwest from MENGERS to STEINBACH, and then westward toward crossings over the FULDA RIVER in the vicinity of NIEDERJOSSA.

(2) The 1/20th MRB(+) will act as the advance party of the regiment preceded by the Regimental Recon Company (Notional). The battalion will move with a minimum of two companies (+) abreast wherever and whenever terrain permits.

(3) The 2/20th MRB (+) will follow lead elements and be prepared to support 1/20th MRB by fire and maneuver, assume mission of 1/20th and/or, when routes exist, on order, deploy abreast 1/20th MRB assuming jointly, responsibility and the mission of advance guard with 1/20th MRB.

(4) 3/20th MRB will follow 2/20th in zone with 2d echelon mission and responsibility.

(5) 4/20th Tk Bn (-) will act as reserve, be prepared to resume command of subordinate units, assume 1st or 2d echelon mission or act as regimental exploitation force, on order.

c. Scenarios.

(1) Symbology. The graphic illustrations of the battle used in the following paragraphs were plotted from the CARMONETTE graphics postprocessor, which was developed for this study. The symbols used in the graphic illustrations were taken directly from FM 21-30, Military Symbols, Appendix E. The symbols used for this study and their meaning are presented in table B-1.

(2) Area 2 Covering Force, T-Tank Battalion TF.

(a) Dispositions of the T-Tank Battalion TF are at figure B-5. A tank company (pure) is located in the north in hasty positions generally situated at the edge of the treeline. In the center is another tank company (pure) dispersed in depth and supported by 10 ITVs under TF control. On the right flank is the mech company (pure) located in depth along the existing treelines. The Scout element is at the eastern edge of a small town that provides good fields of vision over the most likely avenue of approach through the towns of ARZELL and EITERFELD.

(b) Lead elements of the Red motorized rifle regiment are located in the northeast corner of the grid. Red artillery units are also dispersed along the northeastern edge of the grid.

(c) Red preplanned artillery fires supporting the regimental advance began falling during the first minute of the action. At minute 2 Blue direct fire systems engaged the leading elements of the advancing force. After firing one or two rounds, the Blue systems displaced to their second delay position. By minute 5, the Blue forces had destroyed between 15 and 18 Red vehicles (figure B-6). The center tank company had inflicted the majority of these losses on Red and was in the process of withdrawing to its second delay position. Covering fires were provided primarily by TOW systems located to the rear and on the right flank of the TF. By minute 9 between 36 and 40 Red systems, roughly the equivalent of the lead MRB, had been destroyed. All Blue companies were displacing to or had arrived at their second delay position. Blue had lost six vehicles, all IFVs or CFVs (figure B-7).

(d) Eleven minutes later at minute 20, the Red commander committed two reinforced MRBs, and the MRR had advanced about 1 1/2 kilometers. This force had been taken under fire by the northern and center tank companies and the mech company in a "killing zone" located in

Table B-1. CARMONETTE graphics postprocessor symbology.

SYMBOL	DESCRIPTION
	Tank (XM1, T72)
	Heavy APC (IFV, BMP)
	Armored RECON Vehicle (CFV)
	Light APC (M113)
	Heavy AT Missile (ITV, BRDM-2)
	Dismounted Infantry
	Mortars
	Medium artillery
	Heavy artillery
	Multiple rocket launcher
	Forested area
	Urban area
	Dead unit/vehicle indicator

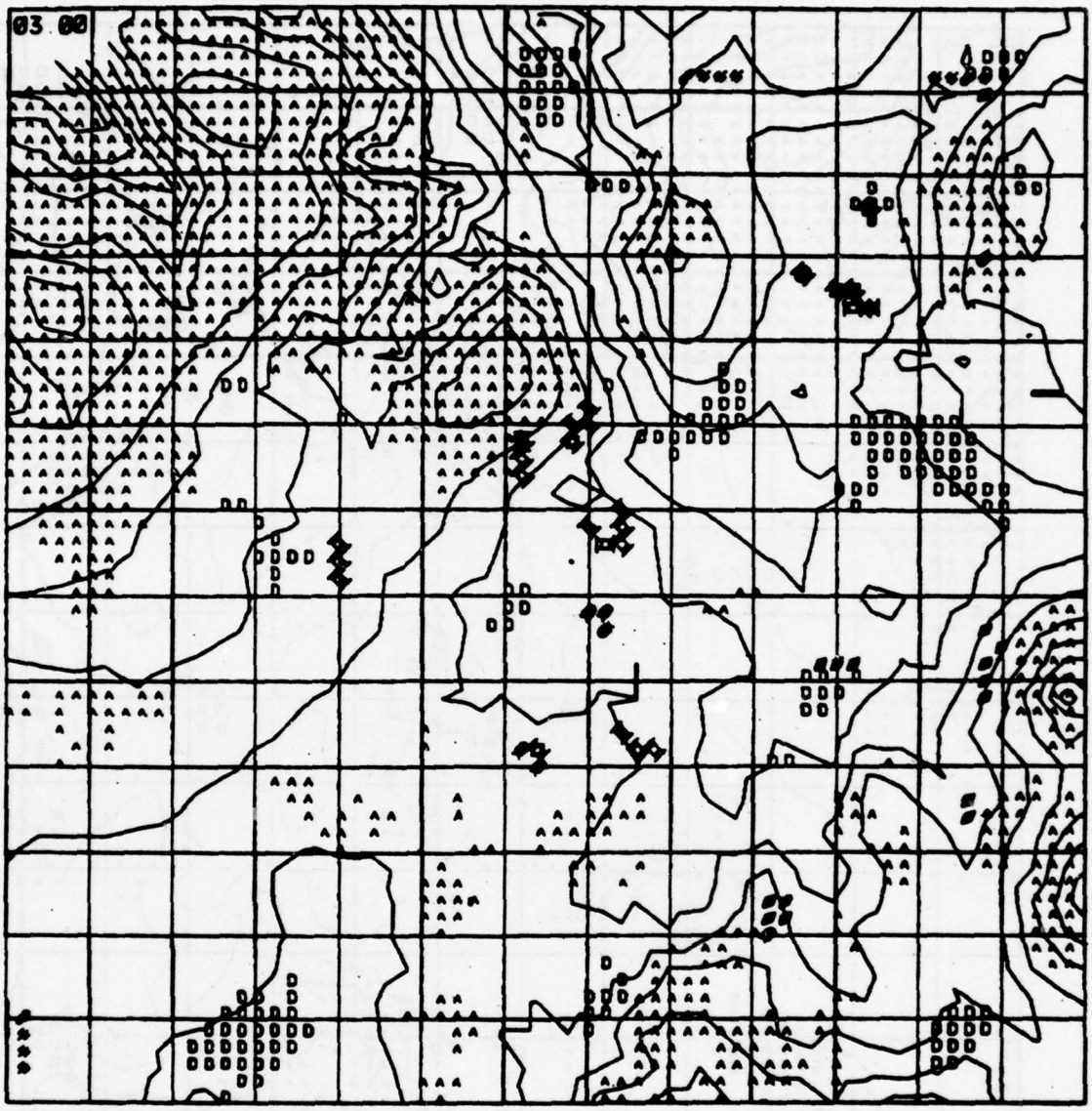


Figure B-5. Initial positions of T-tank in covering force.

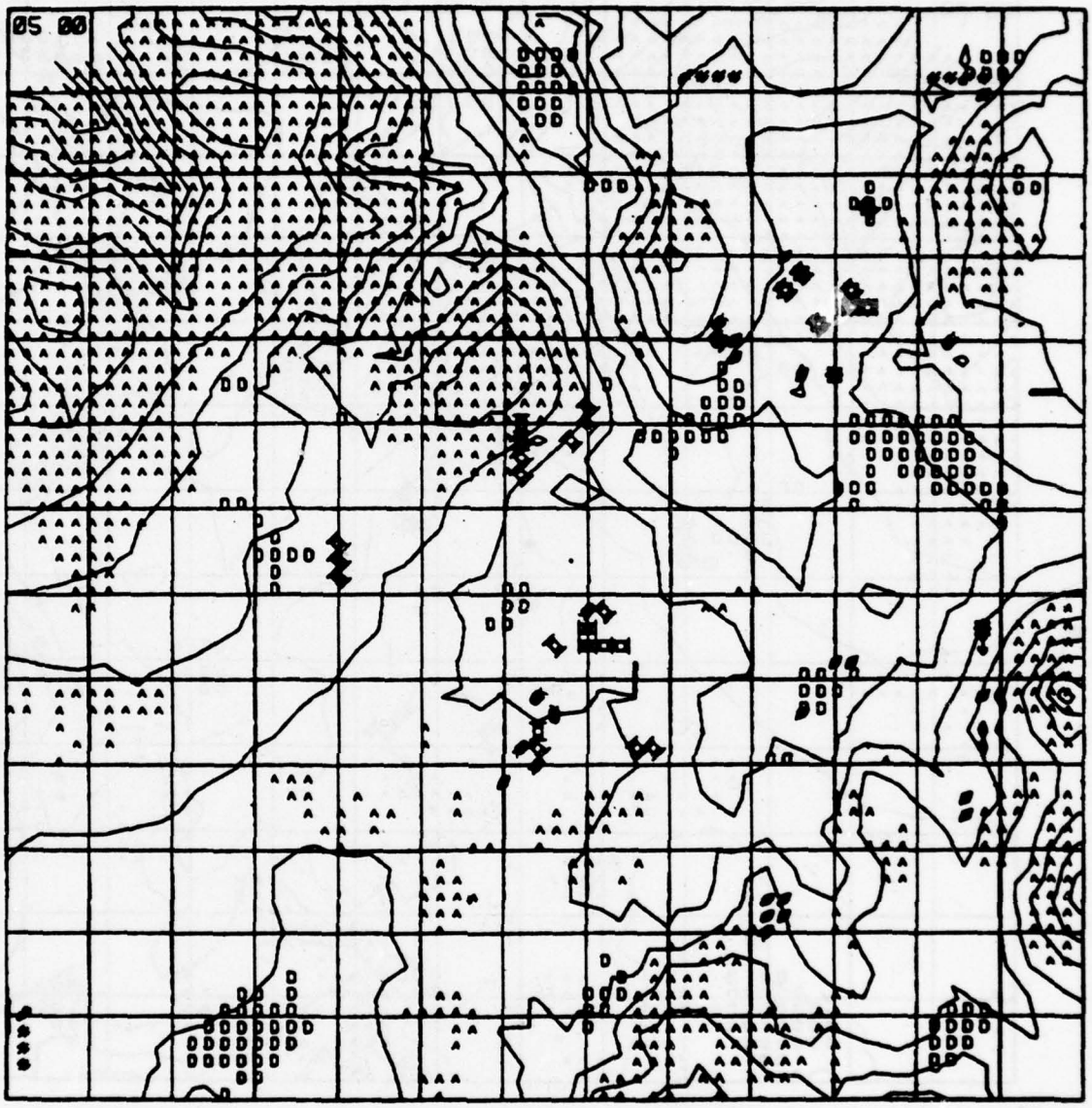


Figure B-6. T-tank covering force action 5 minutes into the battle.

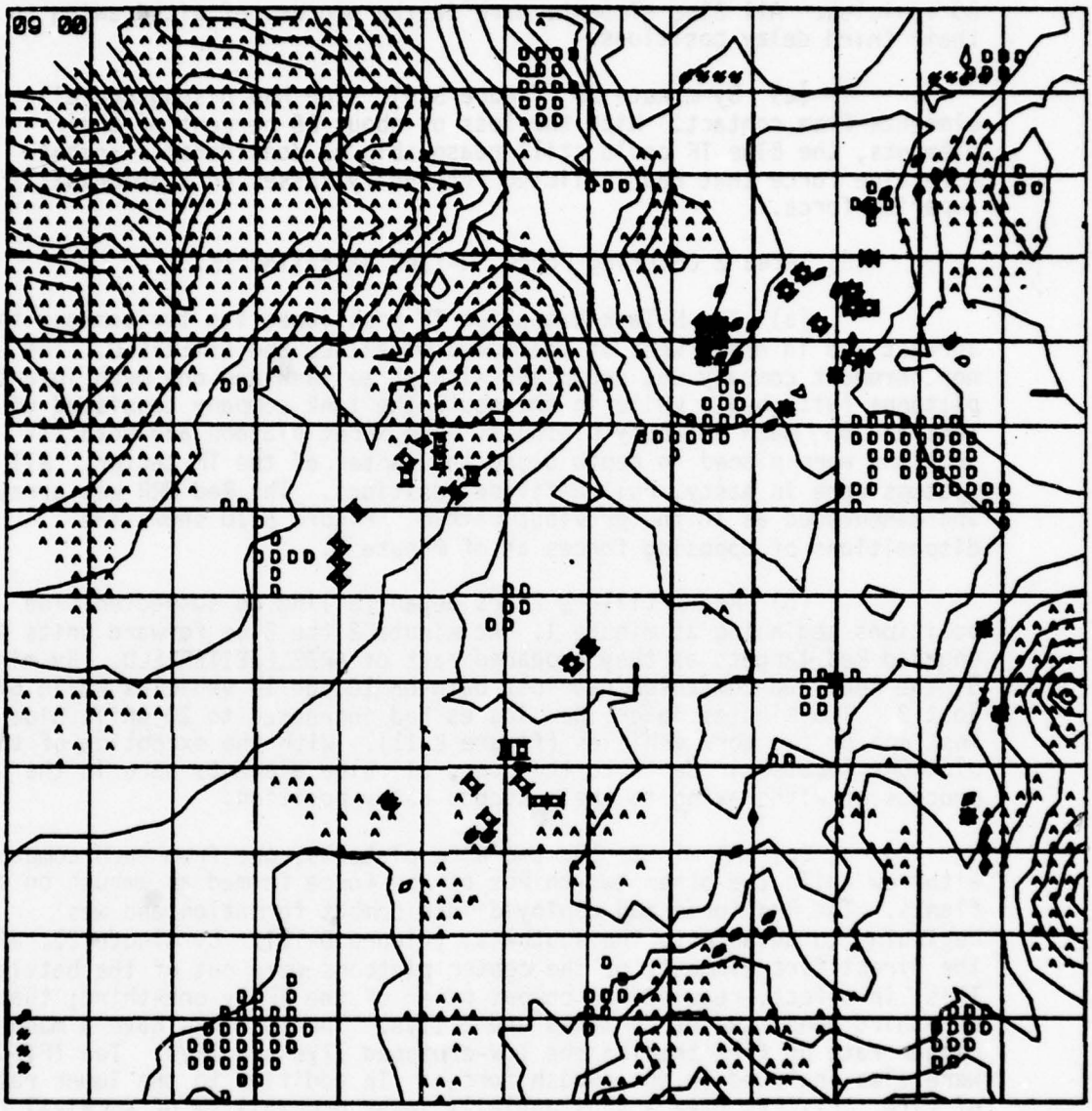


Figure B-7. T-tank covering force action 9 minutes into the battle.

the center of the grid (figure B-8). Red losses had increased to about 50 vehicles. All Blue elements were in the process of withdrawing to their third delay positions.

(e) By minute 25 (figure B-9), Blue had disengaged all elements from contact. With the loss of about 25 percent of their elements, the Blue TF could still reasonably be considered a combat effective force that had inflicted very heavy losses on a numerically superior force.

(3) Area 2 Covering Force, H-Tank Battalion TF.

(a) The H-Tank Battalion TF positioned its two company teams abreast and in depth west of the towns of ARZELL and EITERFELD. The northernmost company was organized with three tank and one mech infantry platoons (attached), while in the south the tank company consisted of two tank and one mech infantry platoons. The Scout platoon and both ITV sections were placed in depth along the center of the TF sector. All systems were in hasty, hull defilade positions. The Red MRR was arrayed and maneuvered as in the previous battle. Figure B-10 shows the dispositions of opposing forces as of minute 3.

(b) Red artillery fires began falling on suspected Blue positions beginning at minute 1. At minute 2 the Blue forward units engaged Red targets as they appeared east of ARZELL/EITERFELD. By minute 5, the Red lead companies had lost between 10 and 12 vehicles while Blue lost 3. Two minutes later, Red losses had increased to 20 while Blue had lost one or two more vehicles (figure B-11). With the exception of the platoons located in depth to the rear, all Blue elements were in the process of withdrawing to their second delay position.

(c) At minute 15, two Blue platoons, one from each company, withdrew while the other two-thirds of the force formed an ambush on the flanks. The Red force had deployed into combat formation and was beginning to advance to the southwest (figure B-12). By minute 20, all the direct fire elements of the center platoons were out of the battle. This, in effect, reduced the combat power of the TF by one-third; that one-third consisted of 10 tanks and 2 ITVs. The 10 tanks have a much higher rate of fire than do the TOW-equipped ITVs and IFVs. Ten IFV/CFVs were also included in the ambush forces. In addition to the lower rate of fire, IFV/CFVs have a substantially lower probability of survival than does the XM1. As a result of the factors noted in the preceding paragraph, the H-series TF lost more vehicles and destroyed fewer enemy vehicles than did the T-series organization.

B-3. SPECIAL SITUATION, AREA 1 (BLUE DEFENSE).

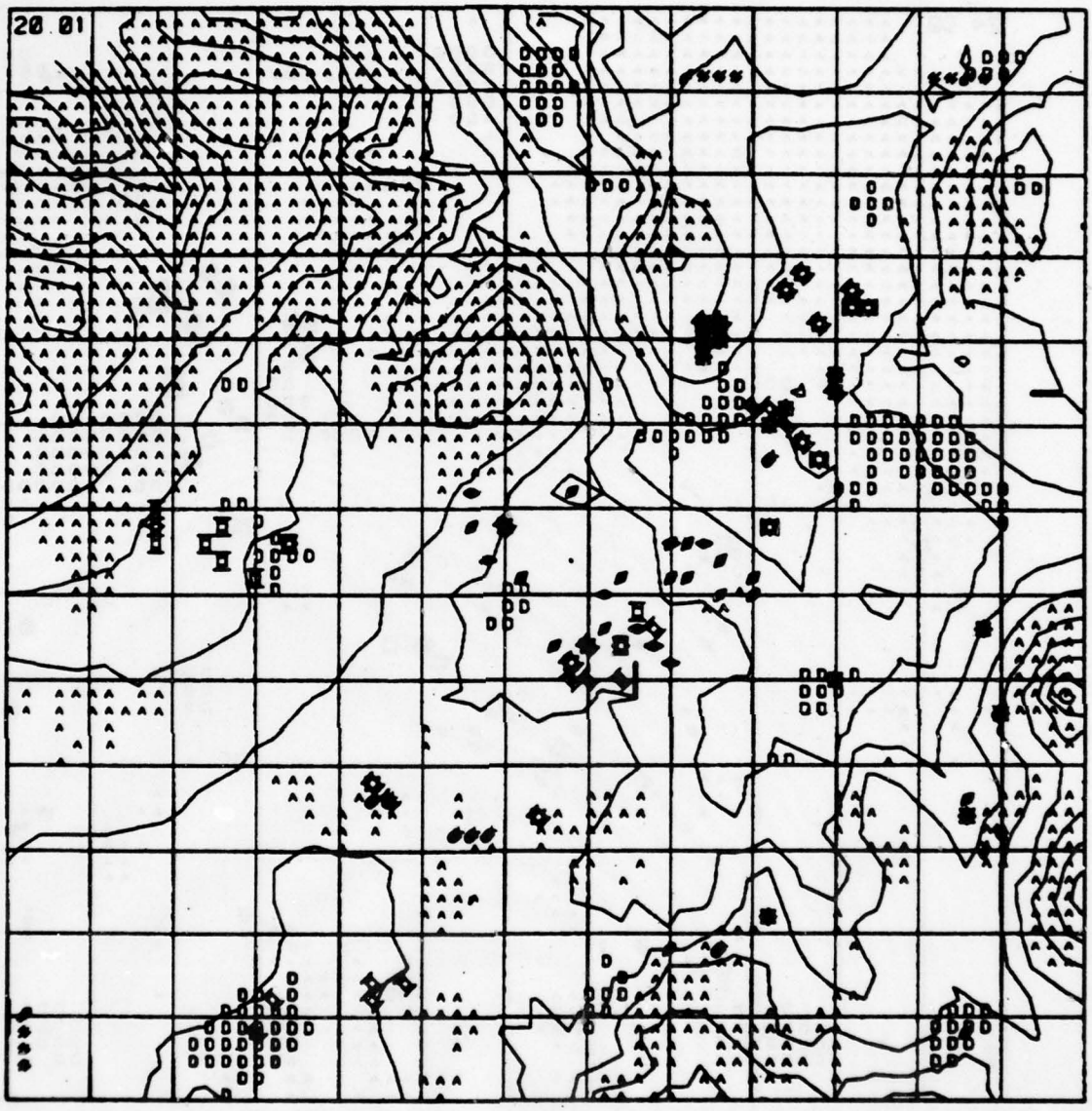


Figure B-8. T-tank covering force action 20 minutes into the battle.

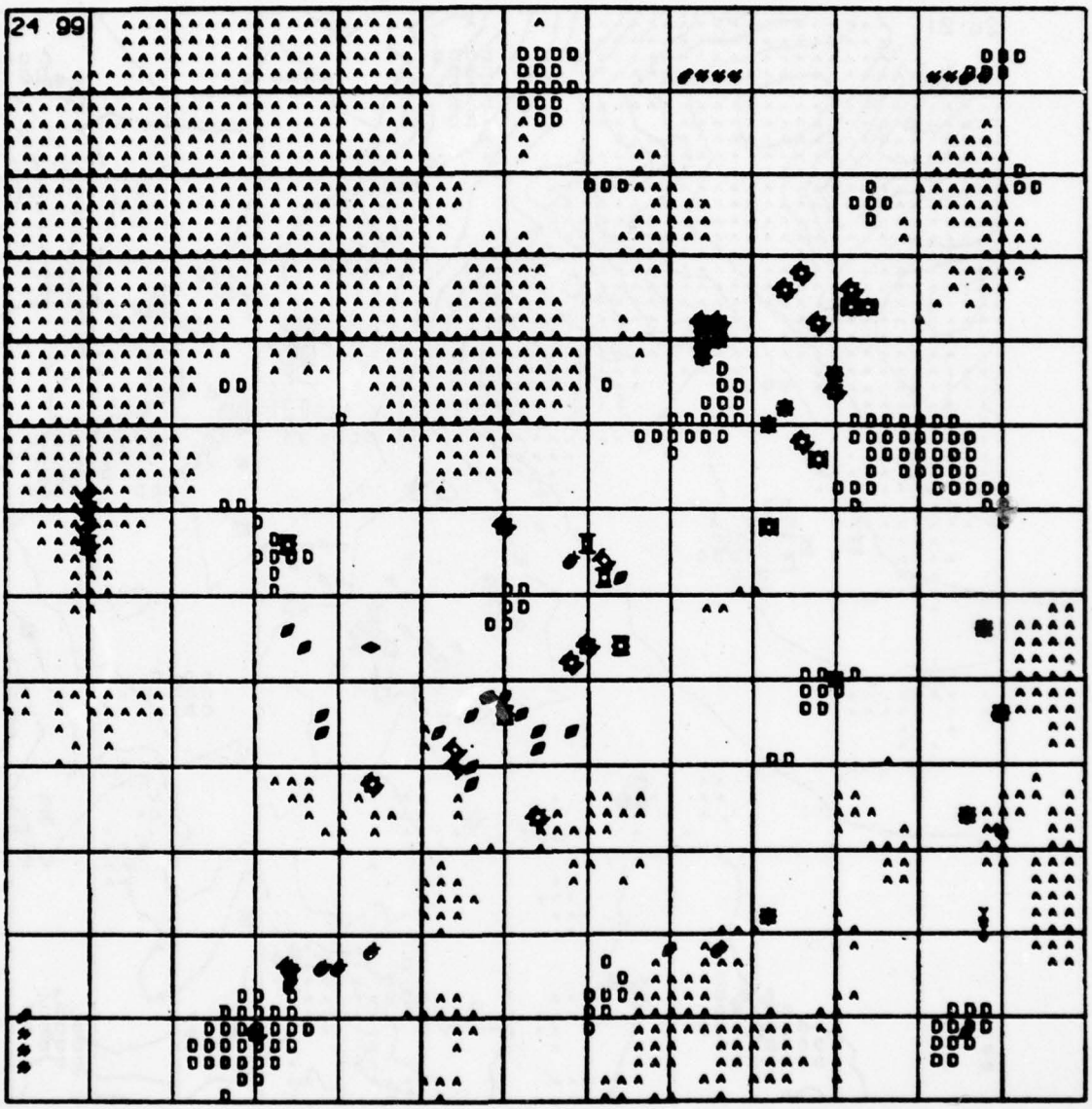


Figure B-9. Dispositions of T-tank at end of covering force actions.

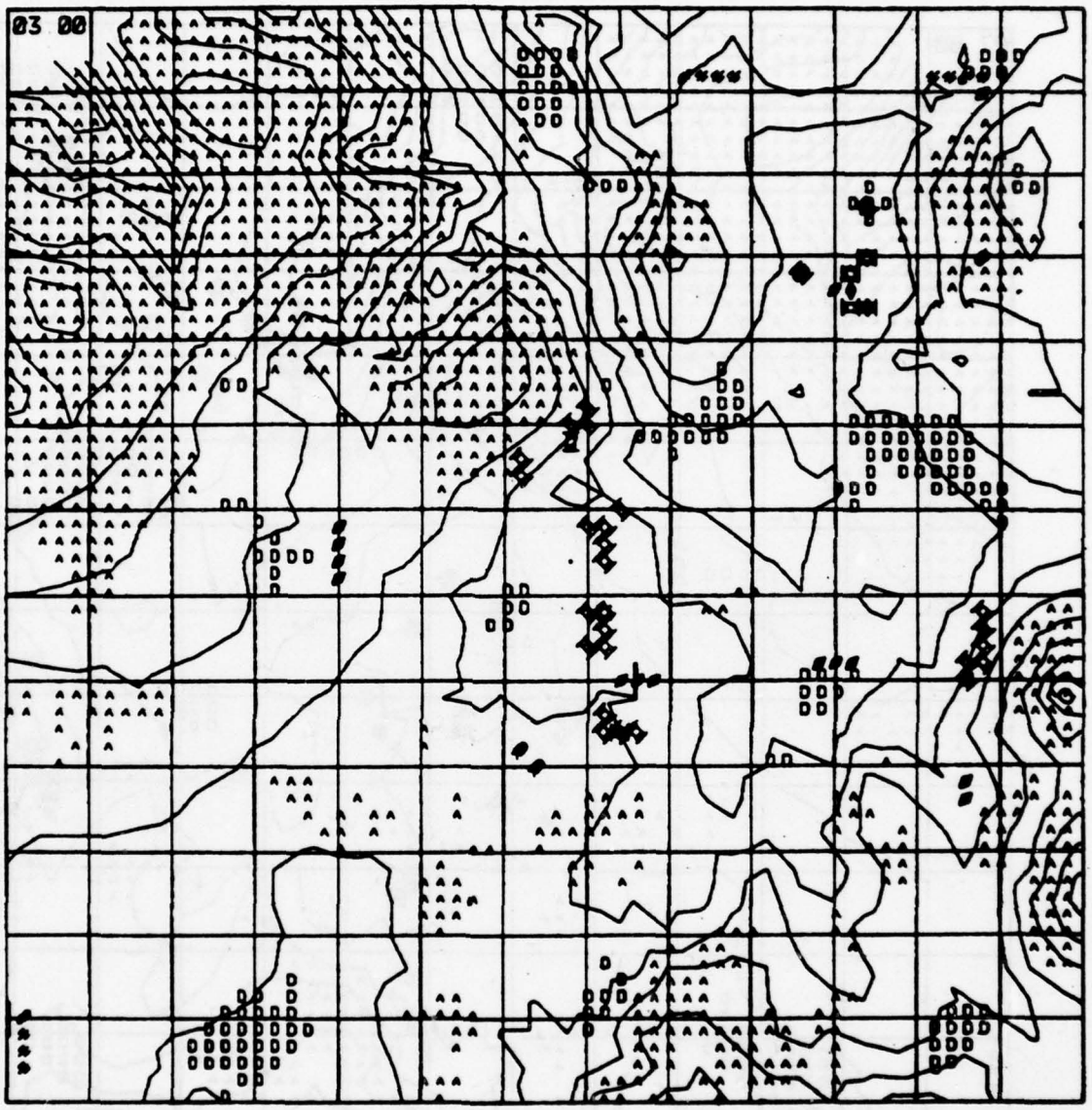


Figure B-10. Initial positions of H-tank in covering force action.

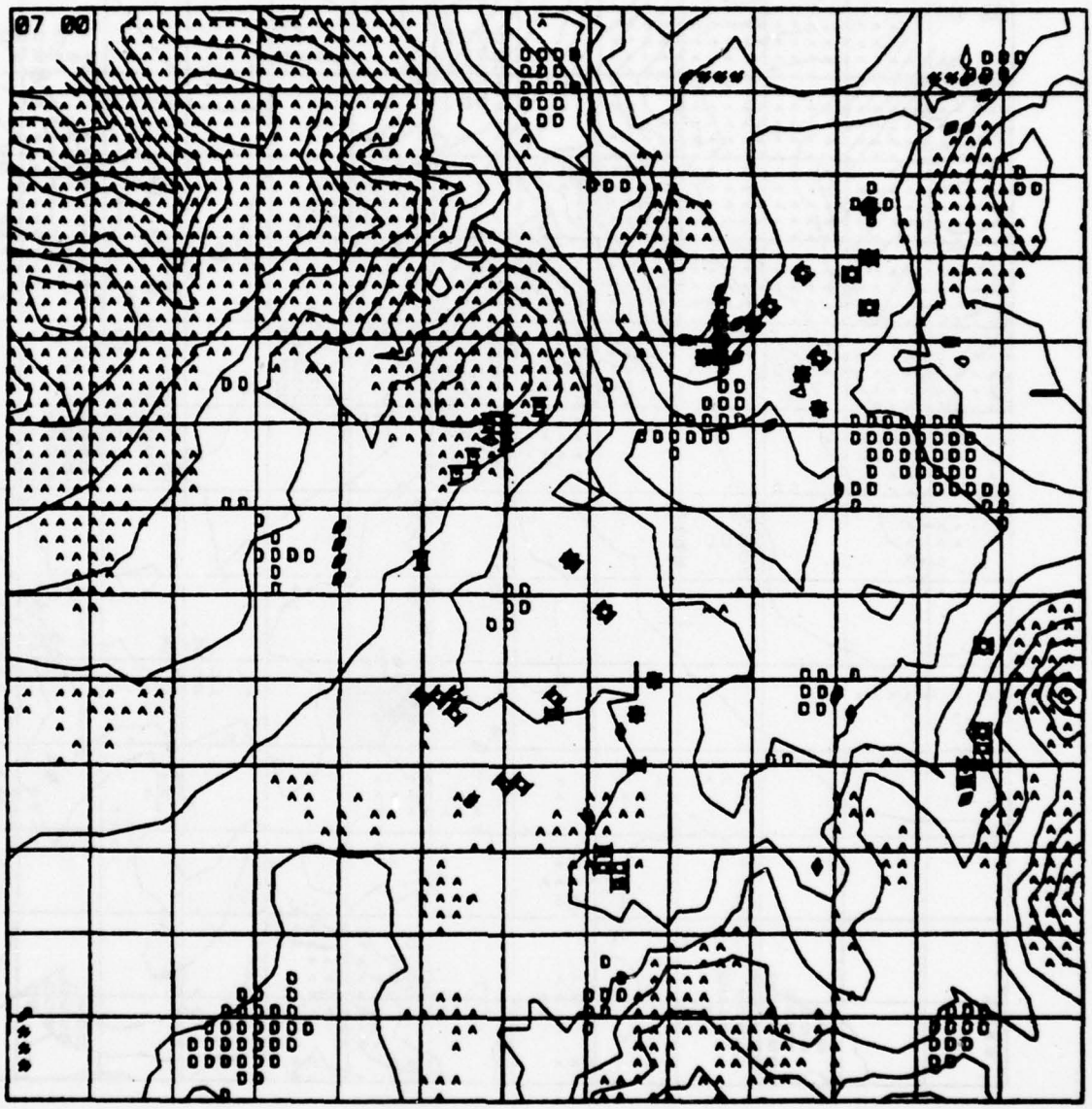


Figure B-11. H-tank covering force action 7 minutes into the battle.

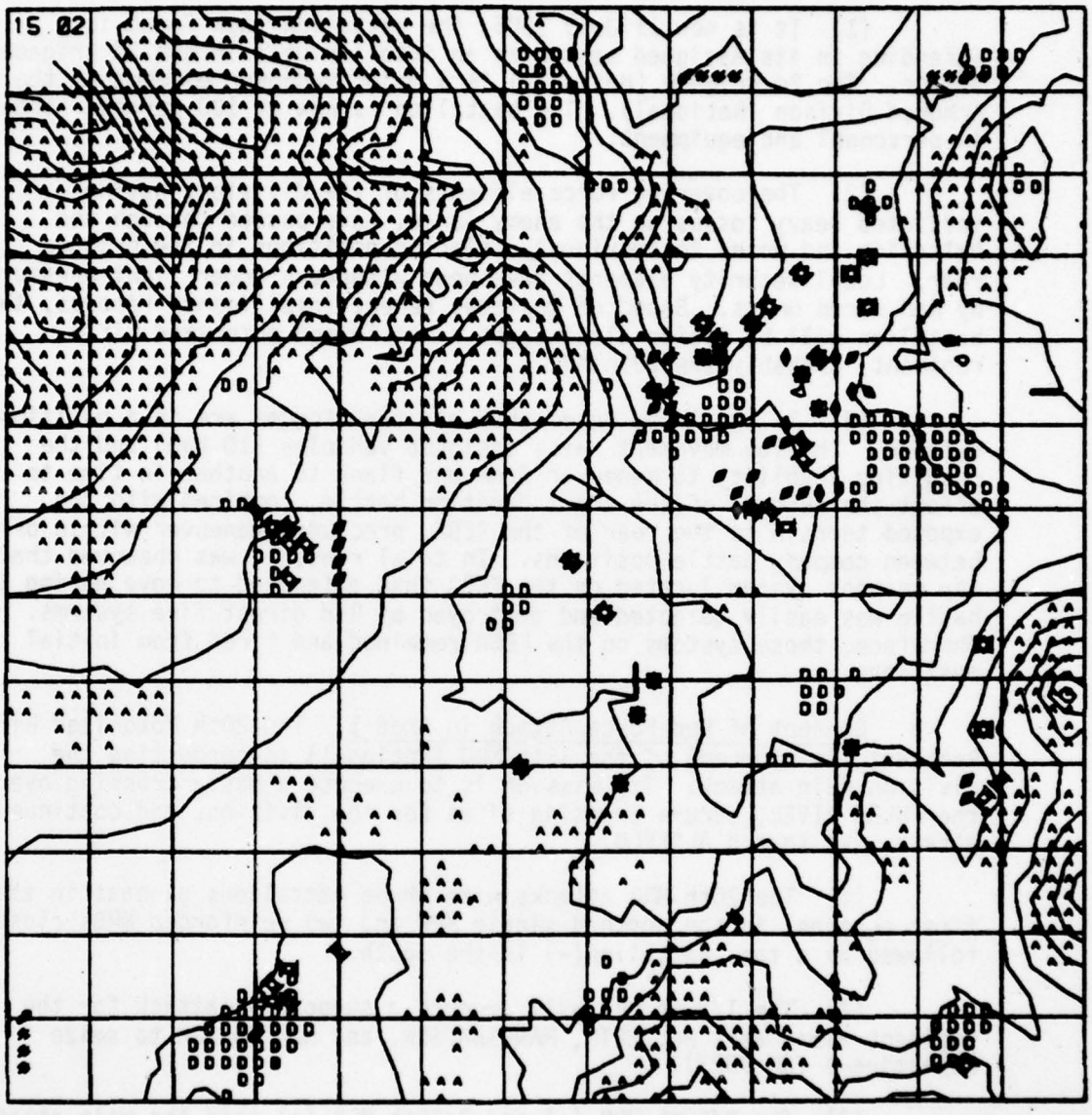


Figure B-12. H-tank covering force action 15 minutes into the battle.

a. Blue Special Situation.

(1) It is now 11 July 1985, the battalion task force is defending in its assigned sector as an interior unit in the 2d Brigade sector. The 2d Brigade (Notional) is a major maneuver element of the 5th Armored Divison (Notional). The battalion is now at 100 percent strength in personnel and equipment.

(2) The covering force elements of the division, having inflicted heavy losses on the enemy force, have passed through the battalion and moved to previously selected positions in the brigade rear. Local security elements have been withdrawn under light pressure by Red recon units. Based on the most recent intelligence reports, the battalion will be facing elements of a reinforced motorized rifle regiment, probably the 20th MRR.

(3) It should be noted that all task forces are in a position defense. The low movement rates assigned vehicles (10 kph) and the resulting inability to maneuver from one flank to another in time to affect the outcome of the short duration battle, combined with the exposed terrain to the rear of the FEBA, precluded maneuver within or between company battle positions. In trial runs, it was observed that any weapons system located on the FEBA that attempted to move during the battle was easily detected and destroyed by Red direct fire systems. Therefore, those systems on the FEBA remained and fired from initial positions.

b. Concept of Red Force Attack in Area 1. The 20th Motorized Rifle Regiment (Reinforced) of the 18th MRD (Notional) is conducting the division main attack. Its mission is to execute a hasty crossing over the FULDA RIVER, secure crossing sites for the division, and continue the attack west toward ALSFELD.

(1) The 20th MRR attacks with three battalions abreast in the first echelon; in the north a single MRB and two reinforced MRBs closely followed by a tank battalion(-) in the south.

(2) The 1/20th MRB will execute a supporting attack for the regiment along axis HOLZHEIM, MANGSHAUSEN, and HOTTENBACH to seize Objective 1 (NM 3828).

(3) The 2/20th MRB (+) and 3/20th MRB (+) lead the main attack in the south supported by the 4/20 Tk Bn (-) with the 2d echelon mission. The axis of advance includes SCHLETZENROD, SOLMS, NIEDERJOSSA, and BREITENBACH to seize Objective 2 (NB 3725).

(4) 4/20 Tk Bn (-) follows as the regimental 2d echelon. It will be prepared to resume control of organic companies, reinforce leading echelons, destroy by-passed enemy centers of resistance, and repulse counterattacks.

(5) Artillery from the RAG and DAG assets will fire a 40-minute preparation.

(6) Air defense artillery will not be arrayed or played.

c. Scenarios.

(1) Area 1 Defense Scenario, T-Tank Battalion TF.

(a) Figure B-13 shows the positions of Blue and Red units as of minute 16 on the CARMONETTE grid. A tank company (pure) is located in the north, a tank company (pure) in the center, and a mechanized infantry company (pure) in the south. In both the north and the south, Blue defenses are anchored on the towns of NIEDERAULA (north) and NIEDERJOSSA (south). IFVs, ITVs, and XM1 tanks are camouflaged in hull defilade firing positions. IFV rifle squads, equipped with Dragons, are positioned within 100 meters of their parent vehicles. All weapon systems with an antitank capability have additional ammunition located at each firing position.

(b) The Red attack opened with heavy preparatory artillery fires designed to destroy the continuity of the defensive complex at the FEBA. As Red units appeared, moving out of the treeline east of the FULDA RIVER, they were taken under fire by all AT weapons systems within range. Concurrently, on-call Blue artillery fires fell on the advancing Red units.

(c) The first 16 minutes of the battle were devoted to movement and deployment of Red units to their line of departure. At minute 16.5 Blue units identified Red moving out of the treeline and opened fire. The southernmost defending company initiated the action as TOW and tank guns opened fire simultaneously.

(d) One minute after the first round was fired, 15 Red armored vehicles had been destroyed and two Blue vehicles had been lost. The first echelon of the Red regiment continued to press the attack along preselected routes supported by very heavy artillery fire that fell on the Blue firing positions. Blue artillery, employed on an on-call basis, fired HE and ICM-DP on the enemy formation. (Figure B-14)

(e) The vast majority of the Red losses were inflicted by Blue direct fire systems. Both Blue and Red artillery were of limited usefulness, although, due to the use of ICM-DP, Blue artillery did

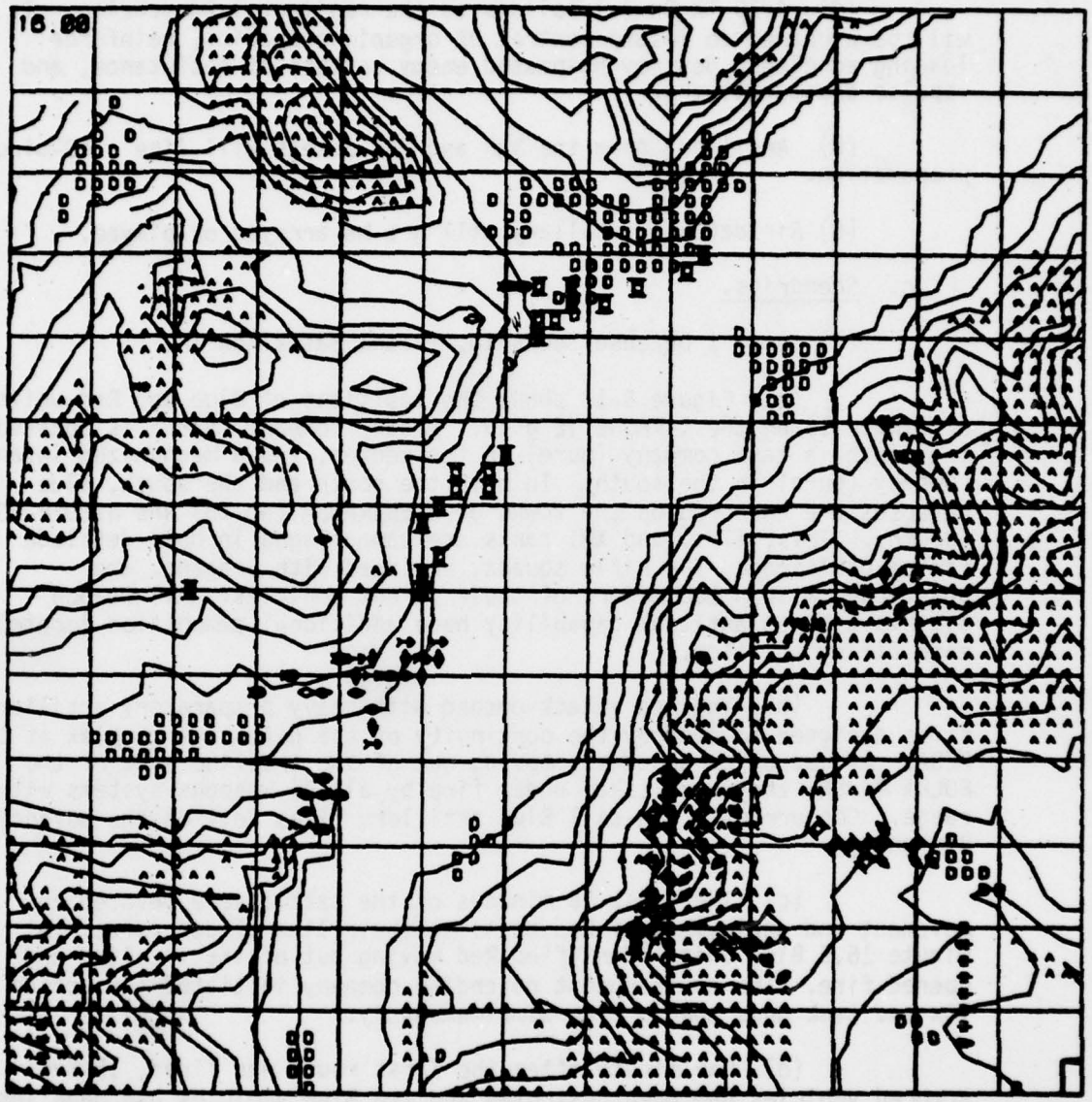


Figure B-13. T-tank battle positions at initiation of contact in position defense.

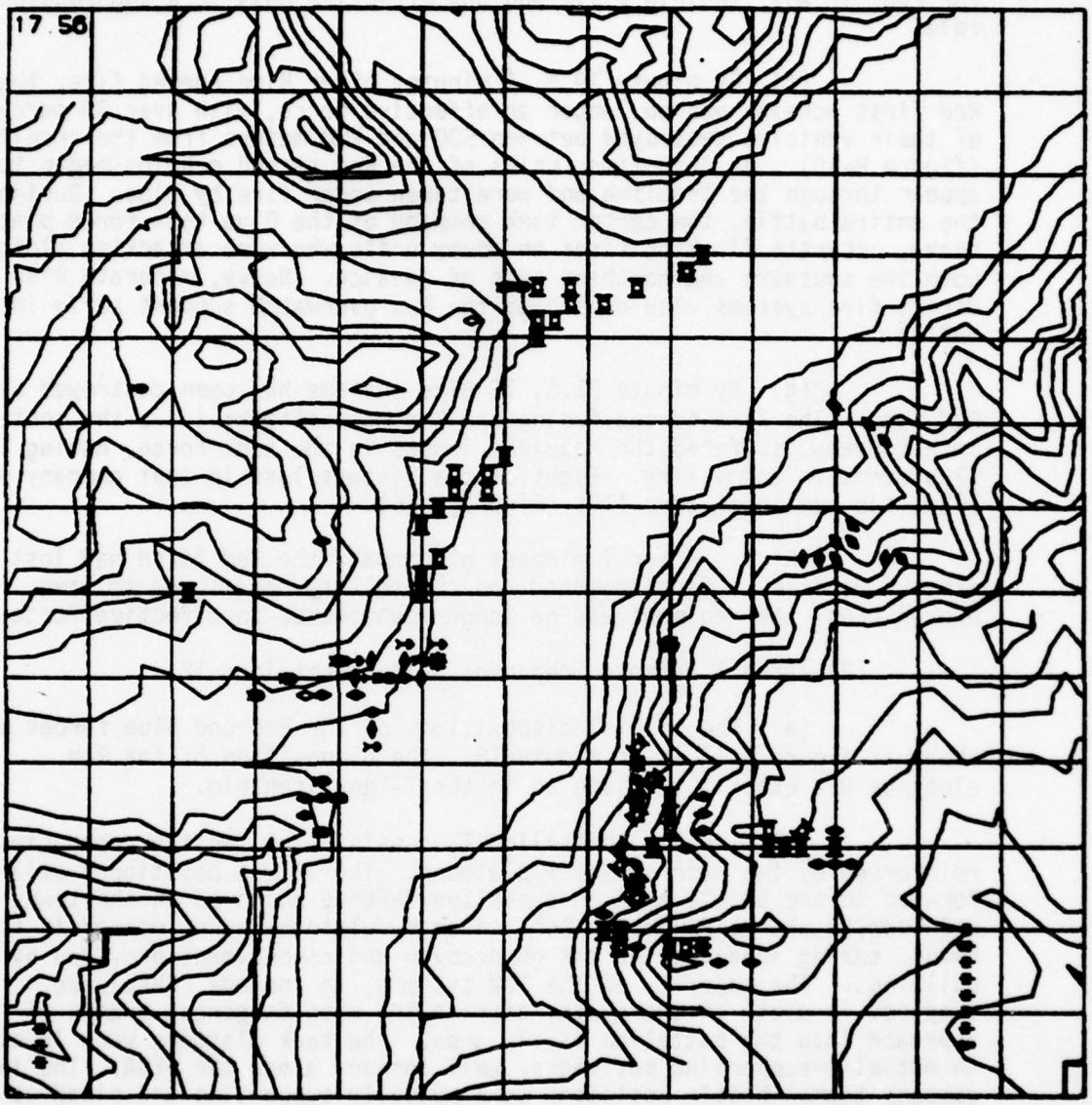


Figure B-14. T-tank battle after the initial exchange of fire in position defense.

contribute a few vehicle kills in each battle. Red artillery accounted for few, if any, vehicle kills and was effective only in a suppression role.

(f) By minute 19.5, 4 minutes after Blue opened fire, the Red first echelon was no longer an effective force, with over 60 percent of their vehicles destroyed between 500 and 700 meters from the treeline (figure B-15). At that time, units of the Red second echelon began to appear through the treeline and were taken under fire by Blue. During the entire battle, the center tank company of the Blue task force placed heavy, accurate flanking fires on enemy units who were attacking along both the southern and northern axes of advance. Heavy, accurate Blue direct fire systems also destroyed the Red overwatch support early in the battle.

(g) By minute 21.5, 18 Blue systems had been destroyed by Red fire. The Blue forces facing the Red main attack; i.e., the southern mech company, suffered the heaviest losses in the task force, having lost 12 systems to enemy fire. Eight of the systems lost in that company were IFVs; the remainder were ITVs (figure B-16).

(h) After 7 minutes of combat, the Red force had lost 100 armored vehicles. Since command and control may be assumed to have broken down, the regiment was no longer considered an effective force.

(2) Area 1 Defense Scenario, H-Tank Battalion TF.

(a) The initial dispositions of the Red and Blue forces are shown at figure B-17 as of minute 16. The disposition of the Red elements was exactly the same as in the T-Tank scenario.

(b) The Blue battalion TF consisted of two tank companies reinforced by two mech infantry platoons. The TF was positioned well forward in the battle area in a positon defense anchored on the towns of NIEDERJOSSA and NIEDERAULA. Both infantry platoons were located in these towns, taking advantage of the good cover and concealment provided by the buildings. The majority of the TOW systems, to include CFVs, were disposed in depth in the south, astride the most dangerous avenue of approach into the battalion battle area. The tank platoons were located in mutually-supporting positions, well forward along the FEBA. The two company teams' battle positions were mutually supporting and sited so as to permit engagement of Red force armor vehicles with flanking fires. One tank platoon in the northern position was earmarked to reinforce the southern team upon order of the battalion commander.

(c) Red forces emerged from the treeline east of the Fulda river at 16.5 minutes and were immediately engaged by Blue TOW and tank systems. By minute 17.6, 35 Red armored vehicles had been destroyed in

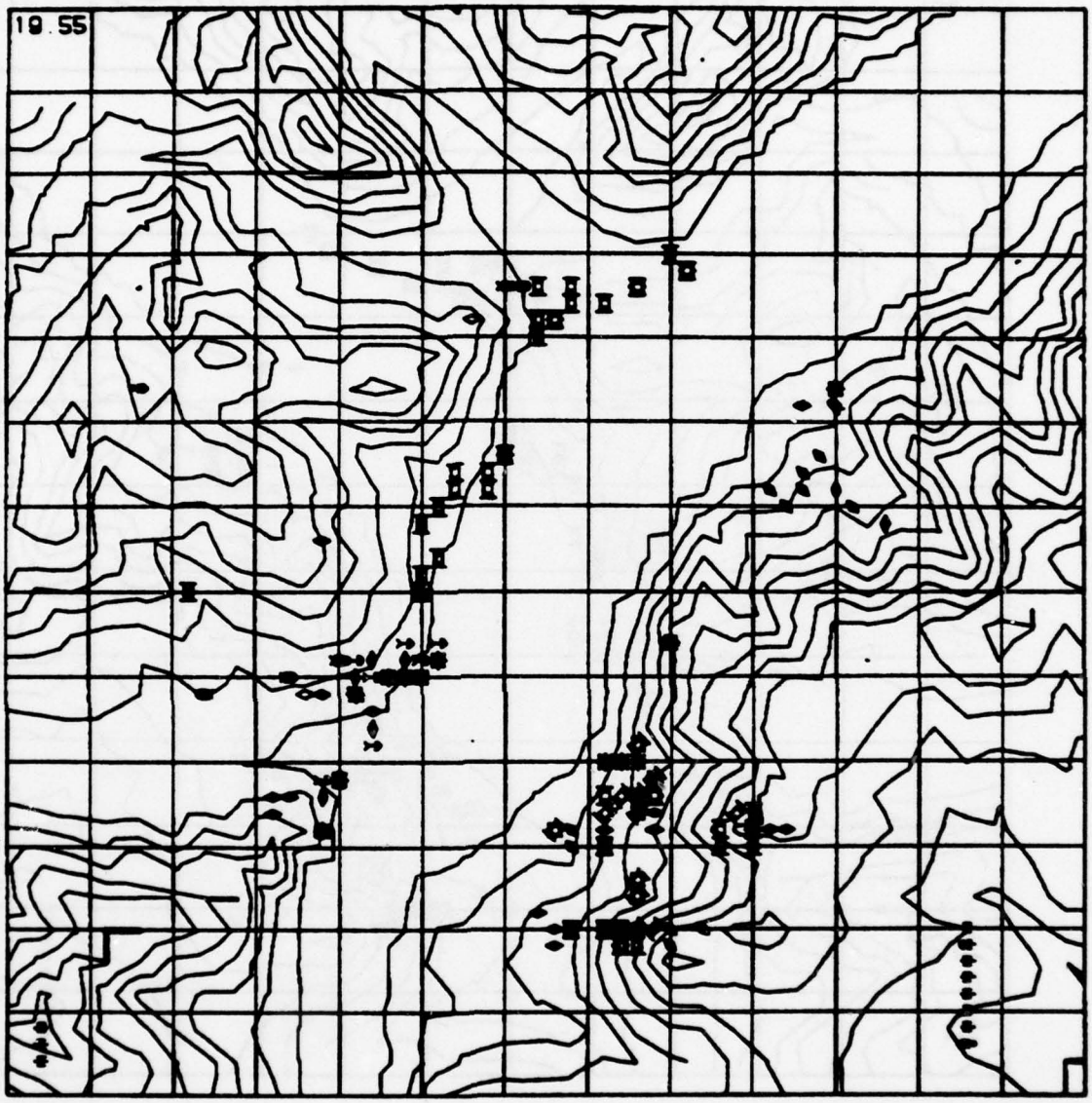


Figure B-15. T-tank in position defense after 4 minutes of battle.

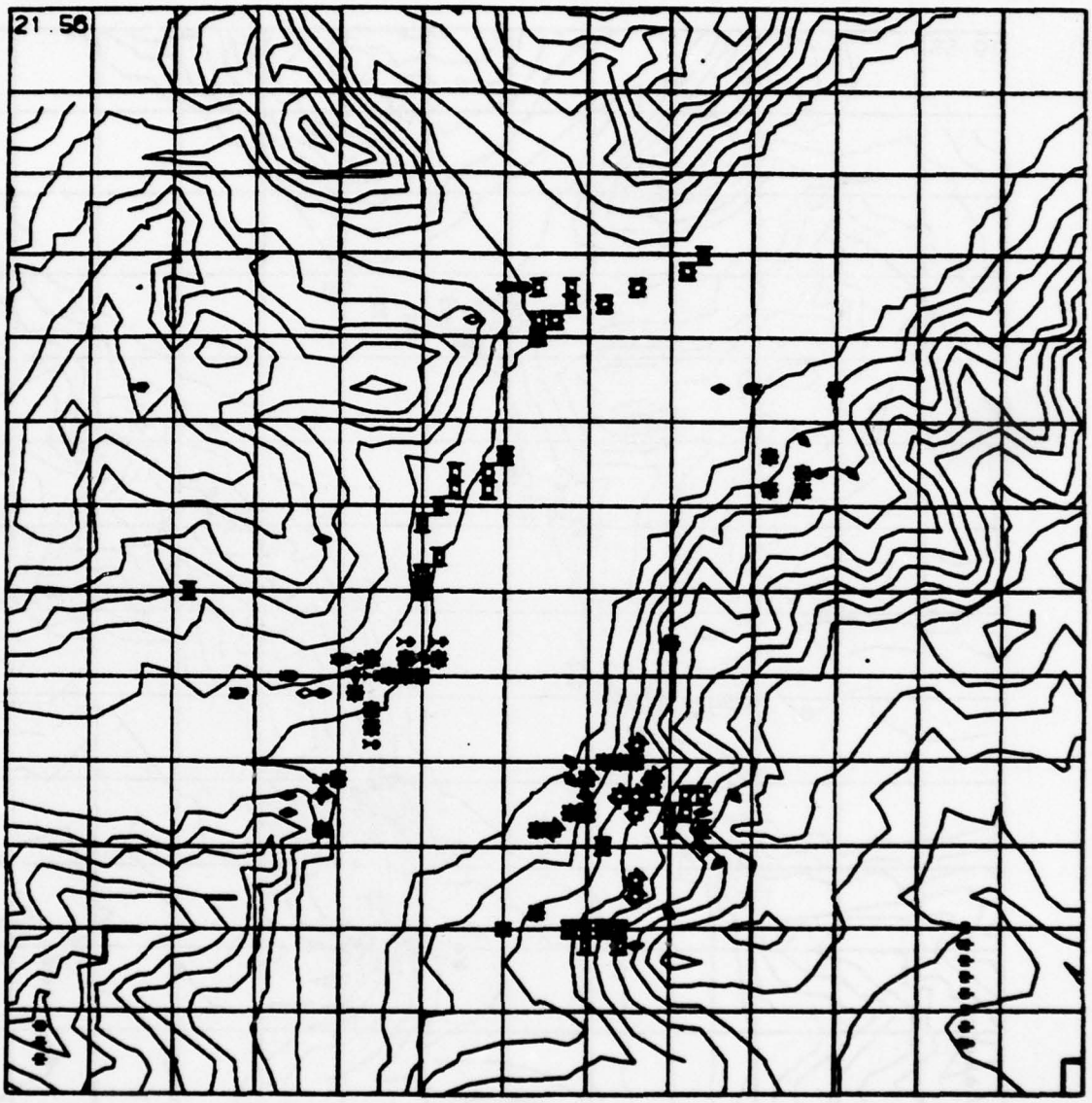


Figure B-16. T-tank in position defense after 6 minutes of contact.

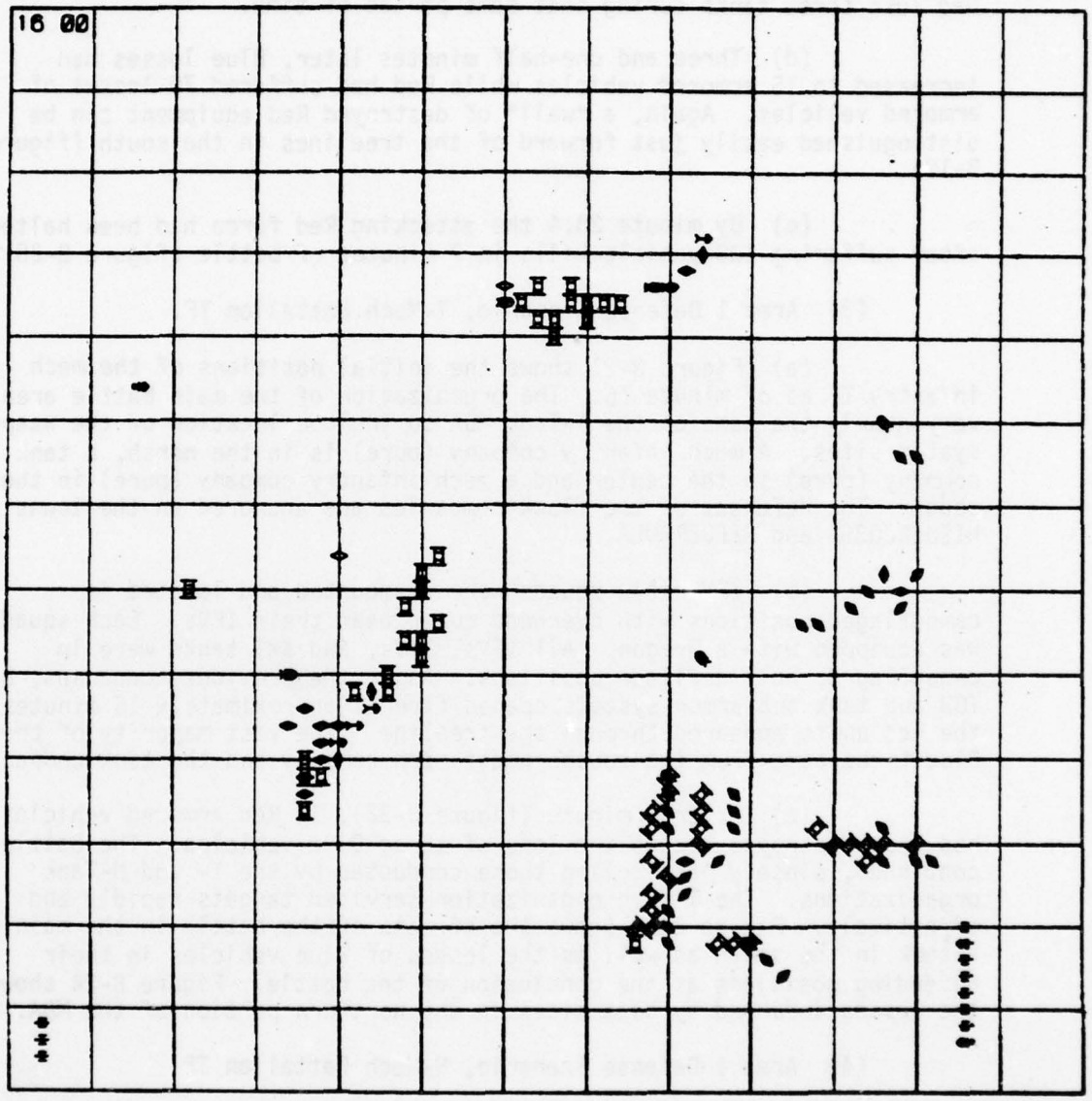


Figure B-17. Disposition of H-tank at initial contact in position defense.

the areas of both the main and supporting attacks (figure B-18). Blue had lost three tanks during that same period of time.

(d) Three and one-half minutes later, Blue losses had increased to 15 armored vehicles while Red had suffered 70 losses of armored vehicles. Again, a "wall" of destroyed Red equipment can be distinguished easily just forward of the treelines in the south (figure B-19).

(e) By minute 23.4 the attacking Red force had been halted after suffering 100 vehicle kills in 7 minutes of battle (figure B-20).

(3) Area 1 Defense Scenario, T-Mech Battalion TF.

(a) Figure B-21 shows the initial positions of the mech infantry TF as of minute 16. The organization of the main battle area is very nearly the same as the T-Tank MBA to include location of the weapons system sites. A mech infantry company (pure) is in the north, a tank company (pure) in the center and a mech infantry company (pure) in the south. The defenses of the flank companies are anchored on the towns of NIEDERJOSSA and NIEDERAULA.

(b) IFV rifle squads were dismounted and located in camouflaged positions with overhead cover near their IFVs. Each squad was equipped with a Dragon. All IFVs, ITVs, and XM1 tanks were in camouflaged, hull defilade positions. As in the previous scenarios, Blue TOW and tank antiarmor systems opened fire at approximately 16 minutes as the Red units appeared through the treeline. The vast majority of the Blue fires came from the southernmost mech company and the tank company.

(c) After 1 minute (figure B-22), 14 Red armored vehicles had been destroyed versus the loss of three Blue vehicles. The battle continued, closely paralleling those conducted by the T- and H-Tank organizations. The T-Mech organization serviced targets rapidly and effectively. Figure B-23 shows the effects of the battle in the main Red attack in the south as well as the losses of Blue vehicles in their defending positions at the conclusion of the battle. Figure B-24 shows the losses incurred by both sides in the northern portion of the MBA.

(4) Area 1 Defense Scenario, H-Mech Battalion TF

(a) The H-Mech TF was positioned as the H-Tank TF. The defense was organized with two mech company teams positioned along the FEBA. Both teams anchored their defenses in the towns of NEIDERJOSSA and NIEDERAULA. Each company team had a tank platoon attached to it. The northern team was organized with two mech infantry and one tank platoons, while in the south, the company was organized with three mech infantry

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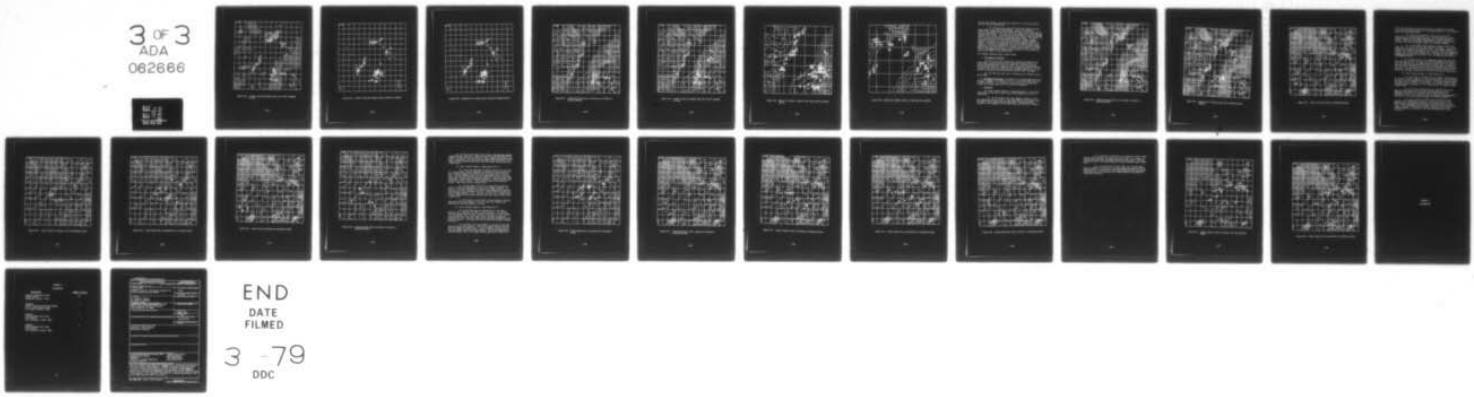

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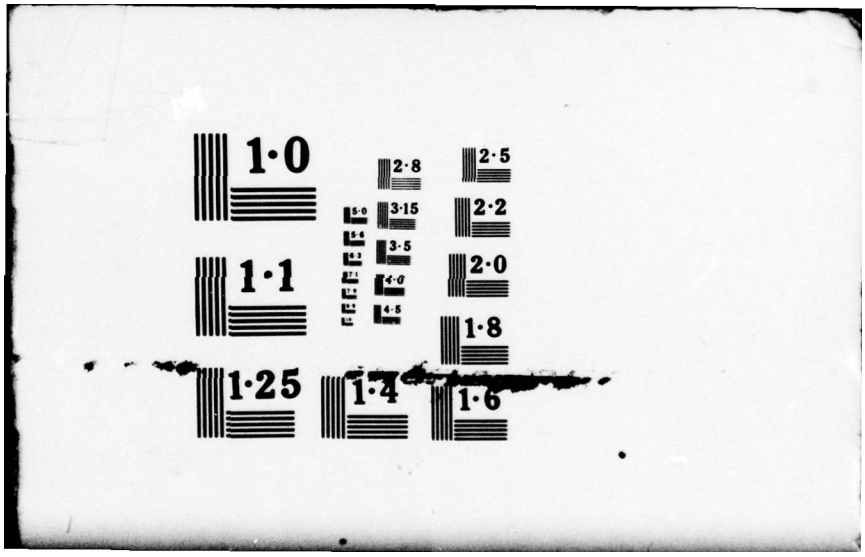
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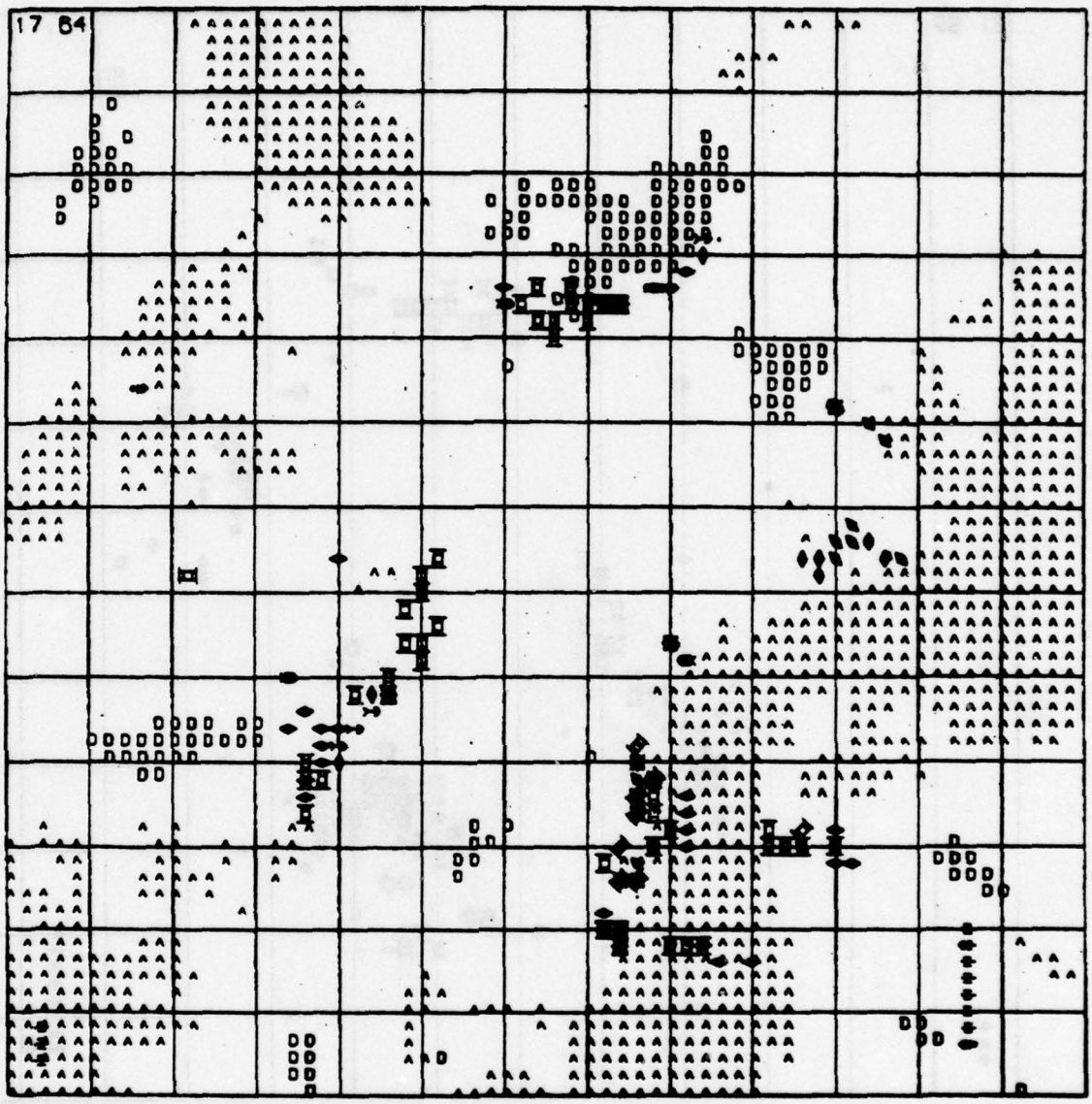

Figure B-18. H-tank in position defense after the initial exchange of fire.

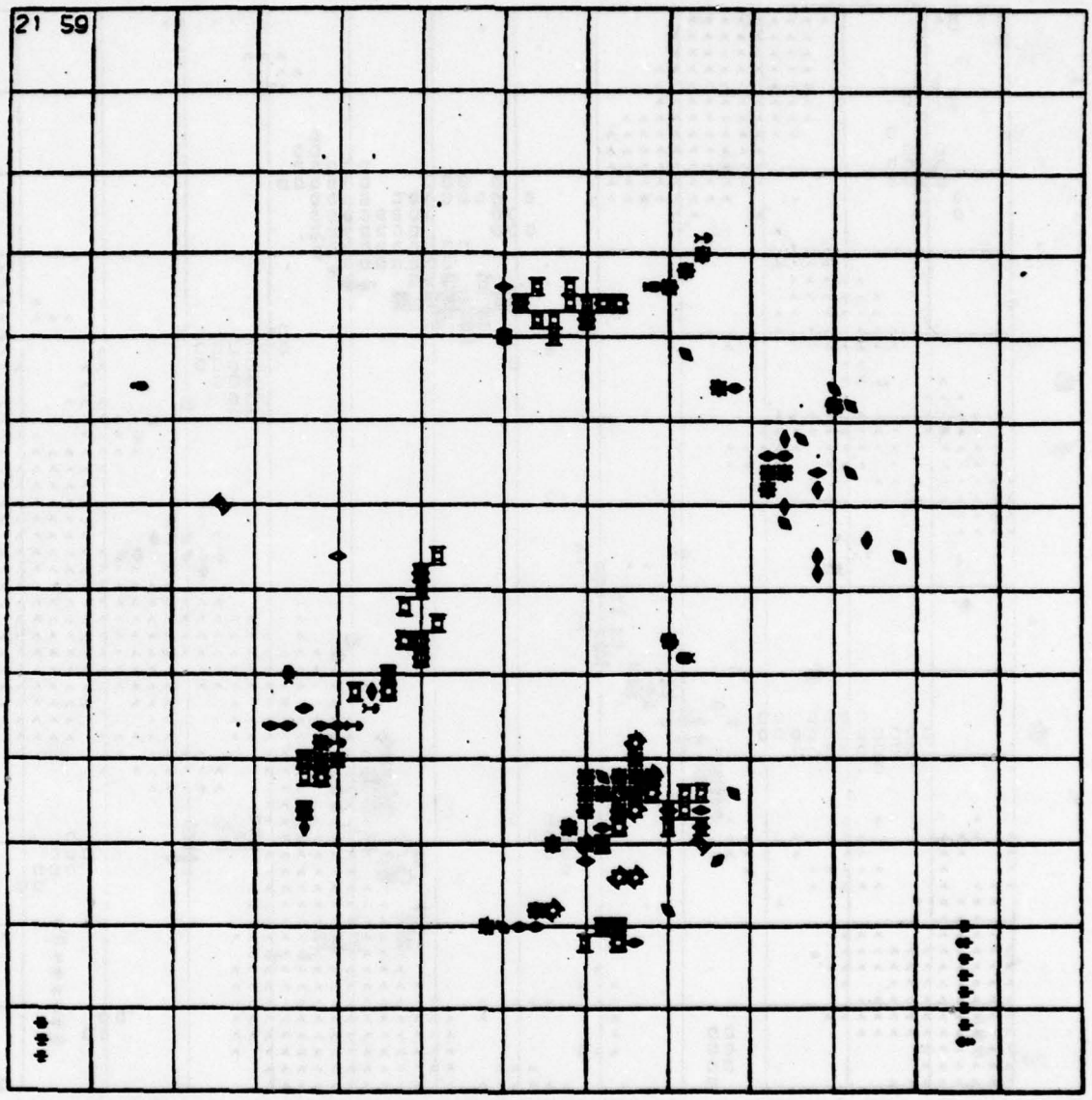

Figure B-19. H-tank in position defense after 5 minutes of contact.

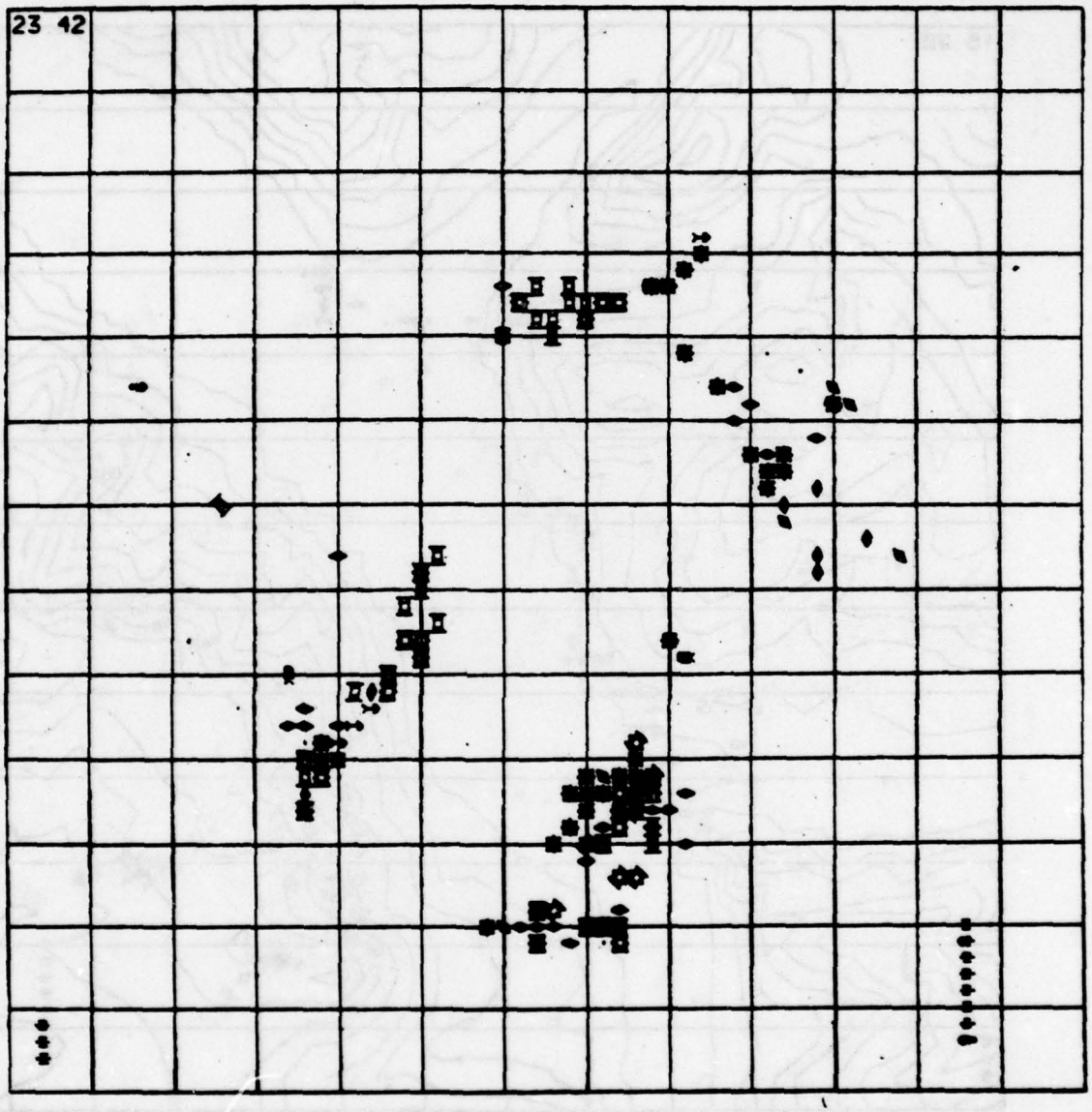

Figure B-20. Disposition of H-tank at end of position defense battle.

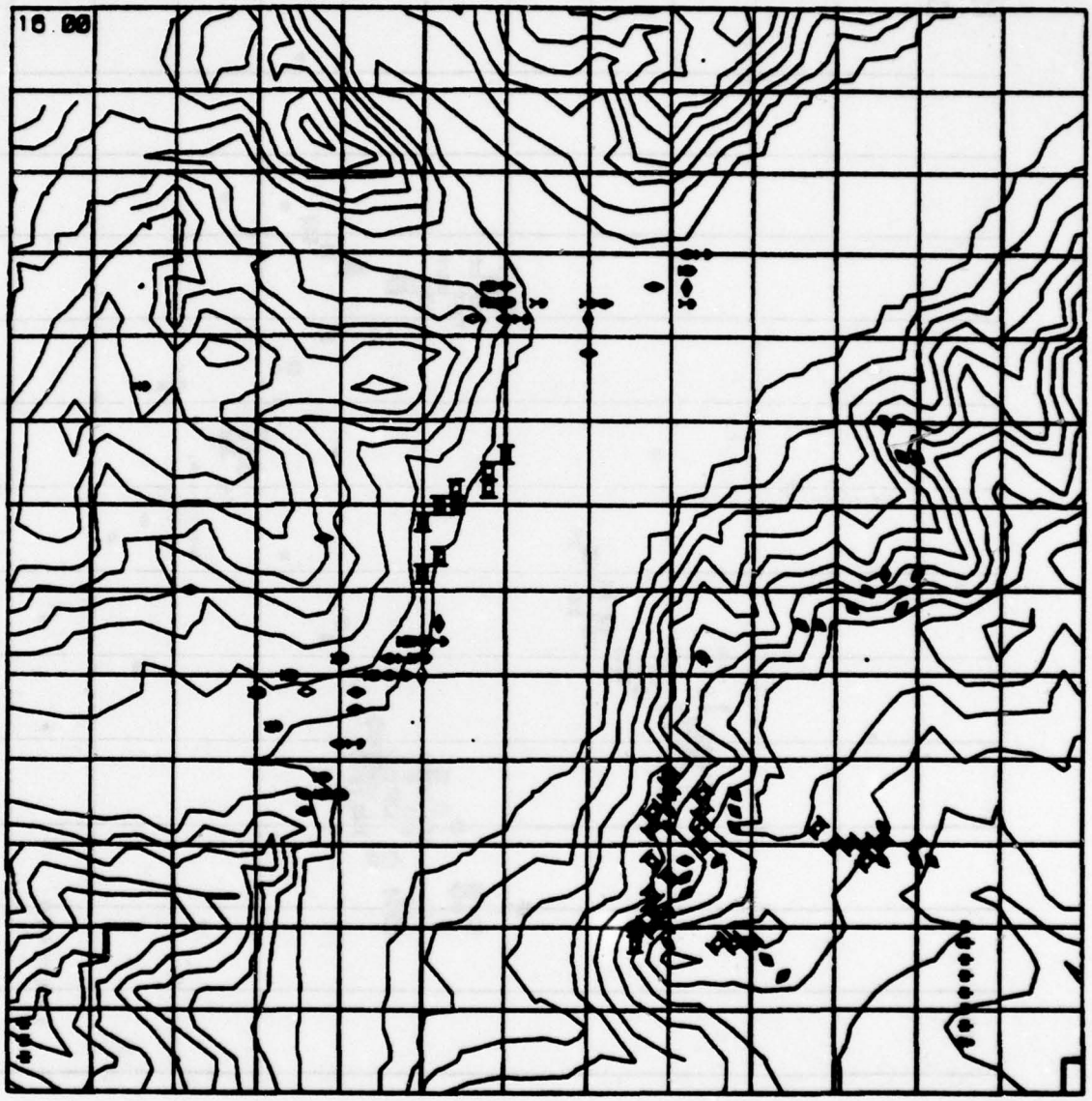

Figure B-21. T-mech battle positions at initiation of contact in position defense.

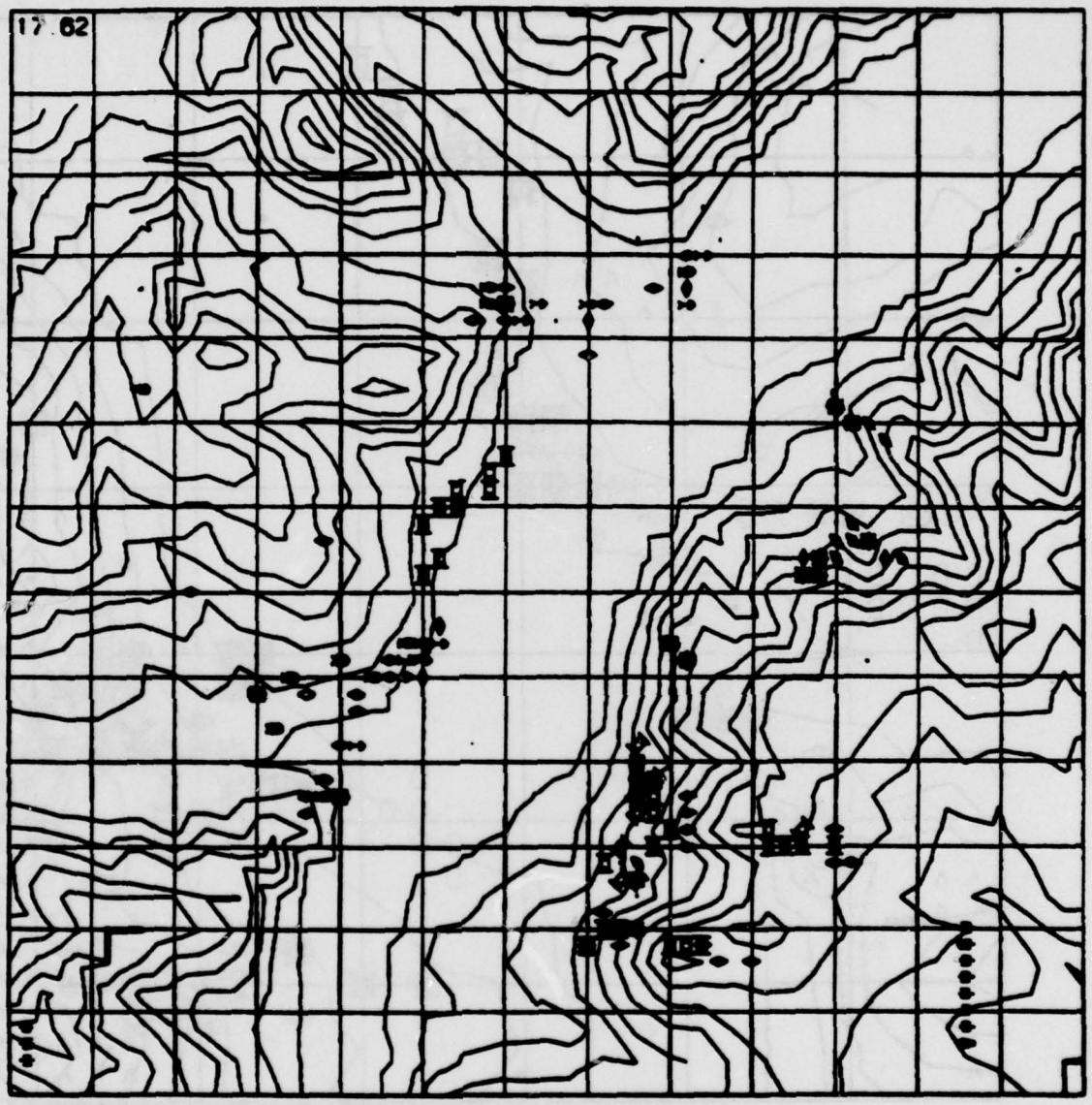

Figure B-22. T-mech in position defense after the initial exchange of fires.

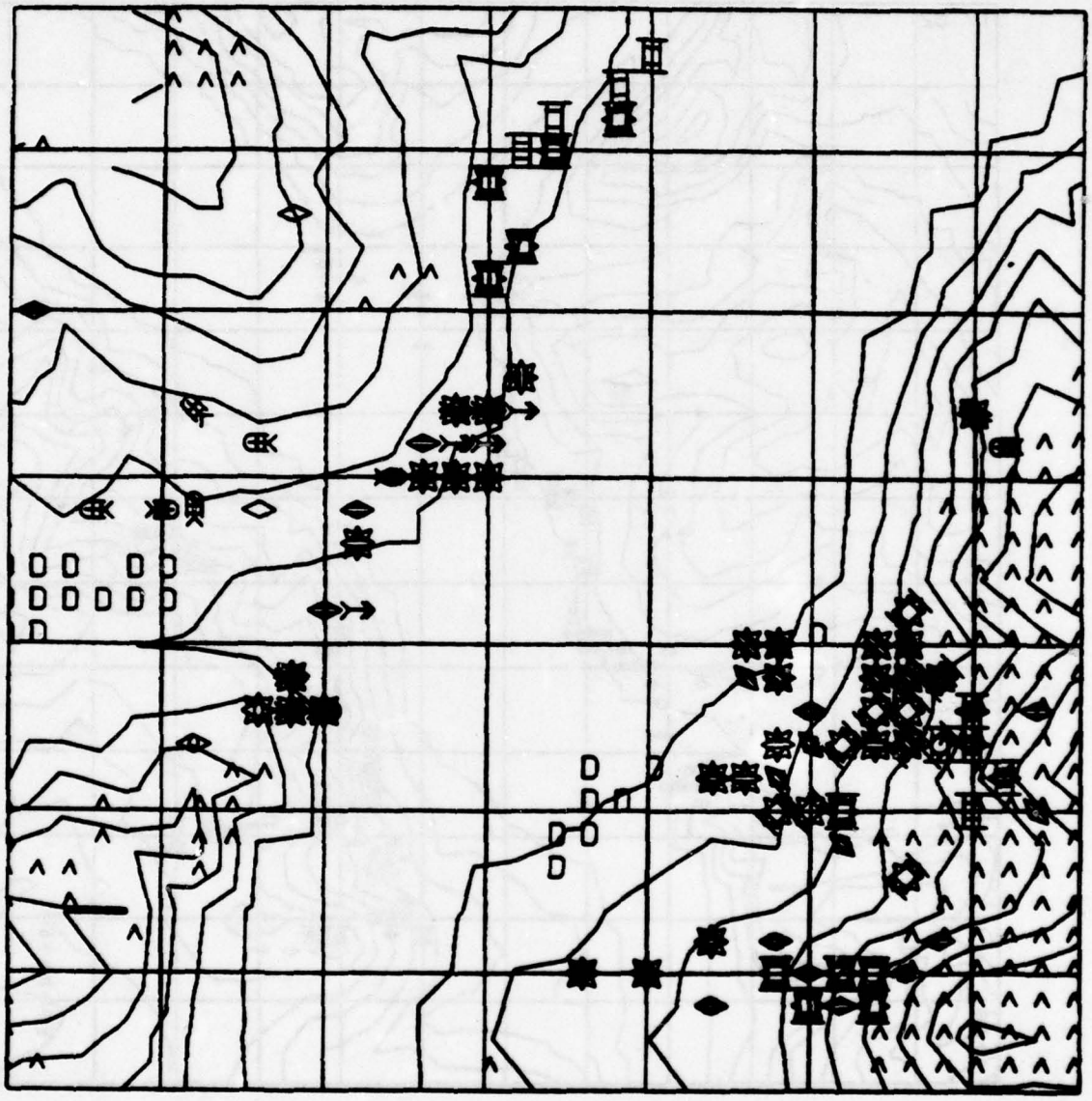

Figure B-23. Results of attack in south of the T-mech position defense battle.

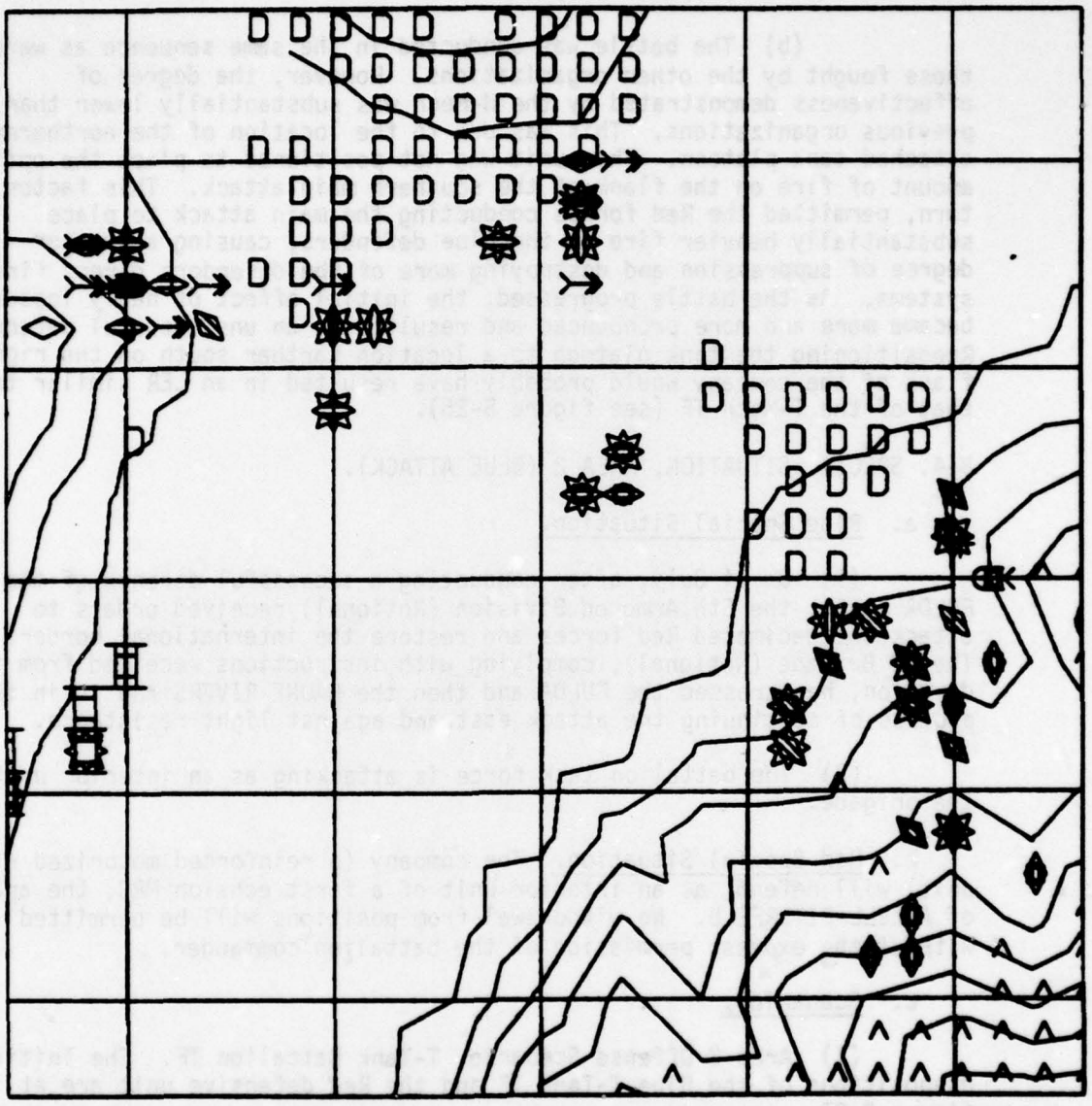

Figure B-24. Results of northern attack in T-mech position defense.

and one tank platoons, and the Scout platoon was six CFVs (see Figure B-25 for intiial dispositions).

(b) The battle was conducted in the same sequence as were those fought by the other organizations. However, the degree of effectiveness demonstrated by the H-Mech was substantially lower than the previous organizations. This was due to the location of the northernmost attached tank platoon. This unit was not positioned to place the optimum amount of fire on the flank of the southern main attack. This factor, in turn, permitted the Red forces conducting the main attack to place substantially heavier fire on the Blue defenders, causing a greater degree of suppression and destroying more of the defenders direct fire systems. As the battle progressed, the initial effect of heavy losses became more and more pronounced and resulted in an unsuccessful defense. Repositioning the tank platoon to a location farther south on the right flank of the company would probably have resulted in an LER similar to that of the T-Mech TF (see figure B-26).

B-4. SPECIAL SITUATION, AREA 2 (BLUE ATTACK).

a. Blue Special Situation.

(1) On 14 July, after conducting a successful defense of the FULDA RIVER, the 5th Armored Division (Notional) received orders to attack the decimated Red forces and restore the international border. The 2d Brigade (Notional), complying with instructions received from the division, has crossed the FULDA and then the HAUNE RIVERS and is in the process of continuing the attack eastward against light resistance.

(2) The battalion task force is attacking as an interior unit of the brigade.

b. Red Special Situation. The company (a reinforced motorized rifle unit) will defend, as an interior unit of a first echelon MRB, the area of ARZELL-EITERFELD. No withdrawal from positions will be permitted without the express permission of the battalion commander.

c. Scenarios.

(1) Area 2 Offense Scenario, T-Tank Battalion TF. The initial dispositions of the Blue T-Tank TF and the Red defensive unit are at figure B-27.

(a) The TF attacked with three companies abreast; a pure tank company on the left flank, a pure tank company in the center, and a pure mech infantry company on the right flank. A TOW section was attached to each company, and two TOW sections were held as TF reserve.

Figure B-25. H-mech battle positions at initiation of contact in position defense.

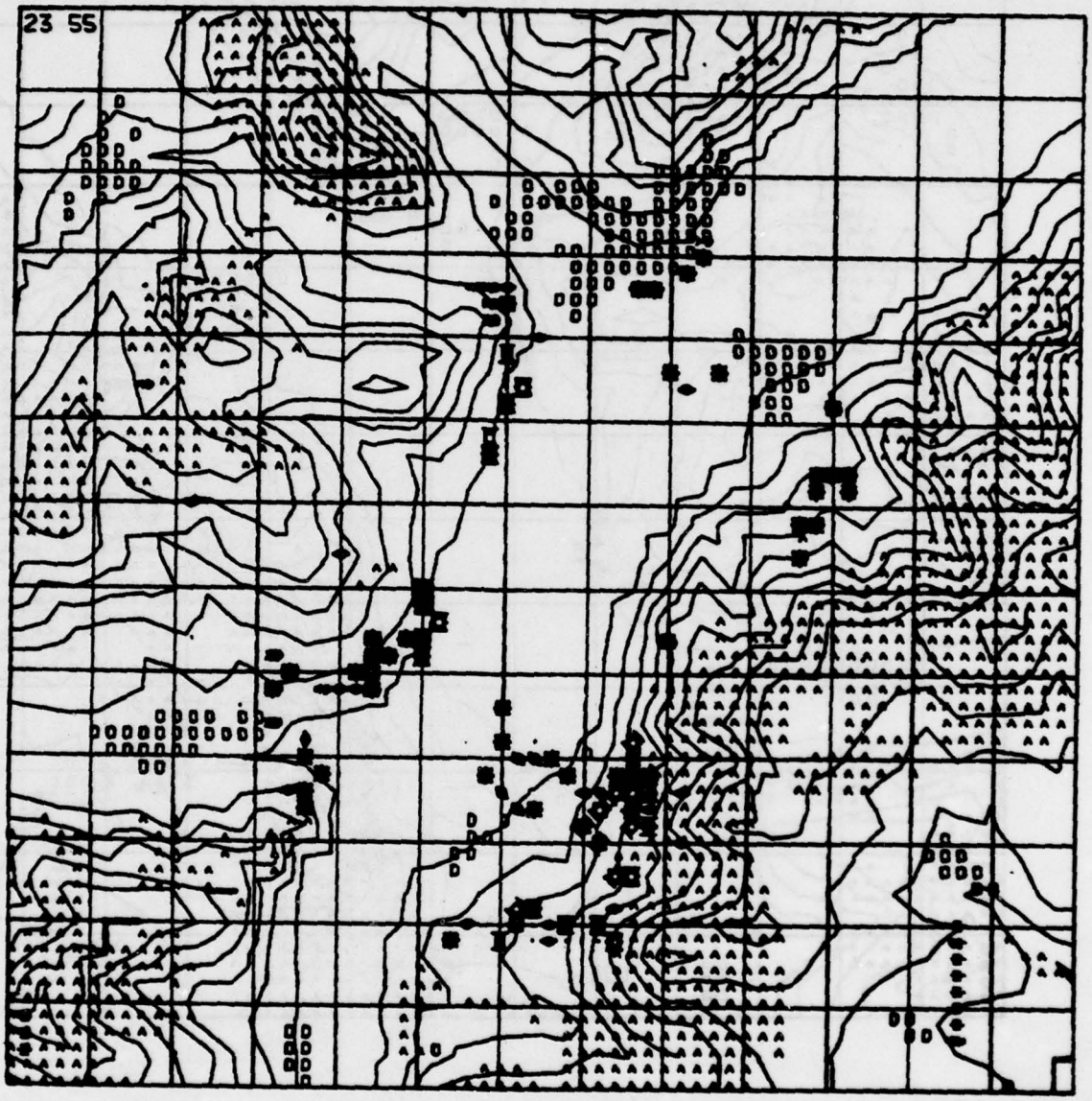

Figure B-26. Disposition of forces at the end of H-mech position defense.

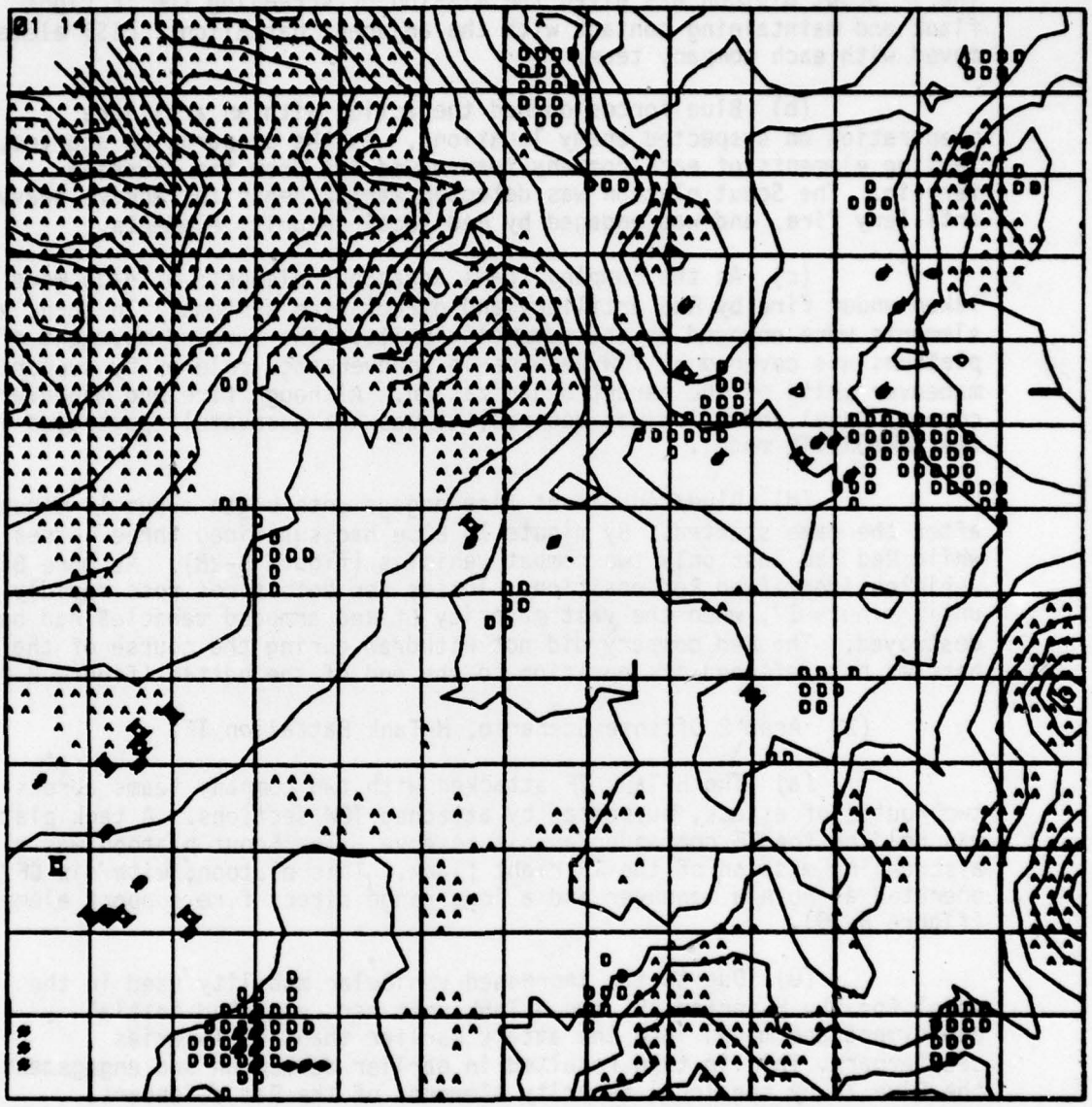

Figure B-27. T-tank initial positions in deliberate attack.

The TF Scout platoon was given the mission of screening the TF right flank and maintaining contact with the adjacent battalion. FIST elements moved with each company team.

(b) Blue forces opened the action with an artillery preparation on suspected enemy locations. As the preparation started, leading elements of each company team moved out from the covering terrain. The Scout platoon was detected early, began to receive heavy artillery fire, and was engaged by Red local security elements.

(c) As the company teams advanced, elements of each were taken under fire by Red artillery and direct fire systems. In turn, Red elements were engaged by the advancing units. The forward movement of platoons was covered by TOW weapons in an overwatch role or by supporting maneuver units of the parent organization. Although fire and maneuver at company level and below was desired, it was not adequately portrayed in the CARMONETTE model.

(d) Blue/Red direct fire engagements began about 10 minutes after the game started. By minute 15 Blue had sustained three losses while Red had lost only two combat vehicles (figure B-28). As more Blue vehicles identified Red positions, losses for both sides rose rapidly, until minute 17, when the vast majority of Red armored vehicles had been destroyed. The Red company did not withdraw during the course of the battles but defended its position to the end of the battle (figure B-29).

(2) Area 2 Offense Scenario, H-Tank Battalion TF.

(a) The H-Tank TF attacked with two company teams abreast on two routes of attack, supported by attached TOW sections. A tank platoon was held by the TF commander as his reserve. The Scout platoon was given a screening mission of the TF right flank. This platoon, with six CFVs, operated as both a maneuver and a long range direct fire support element (figure B-30).

(b) Due to the increased vehicular mobility used in the model for the H-series TF, the H-Tank unit had completed initial deployment and moved into the attack earlier than its T-series counterpart. This in turn resulted in earlier detection and engagement of the Blue TF by the local security elements of the Red defenders.

(c) Blue initiated the attack with 15-minute artillery preparation on suspected Red locations. By minute 8, each of the opposing forces had engaged and destroyed two enemy vehicles (figure B-31). Those engagements occurred about 2 minutes earlier than did the T-Tank TF battles. Throughout the series, these early Blue losses remained constant and resulted in the less favorable LERs for the H-series TF.

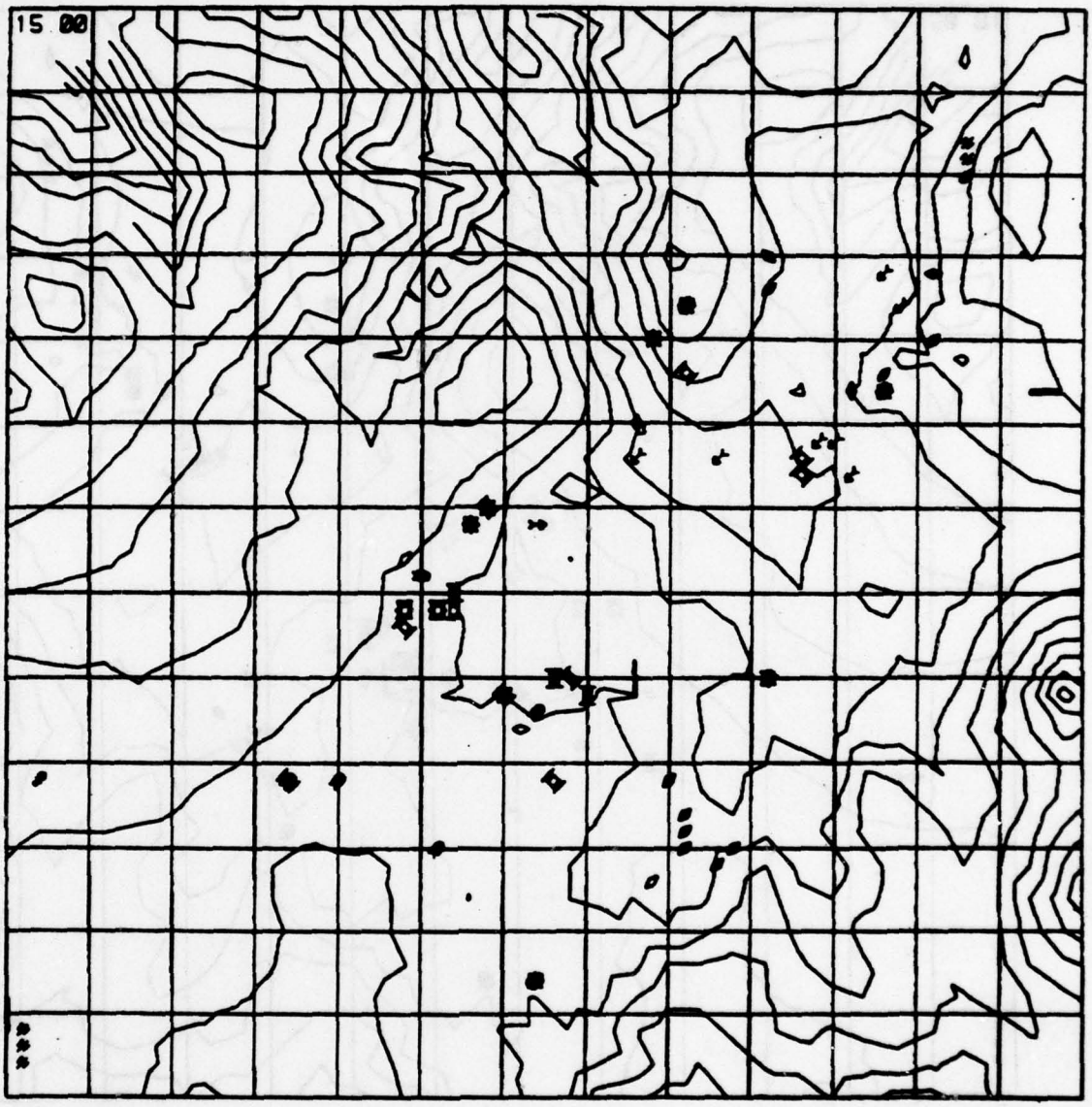

Figure B-28. T-tank situation 15 minutes into the deliberate attack.

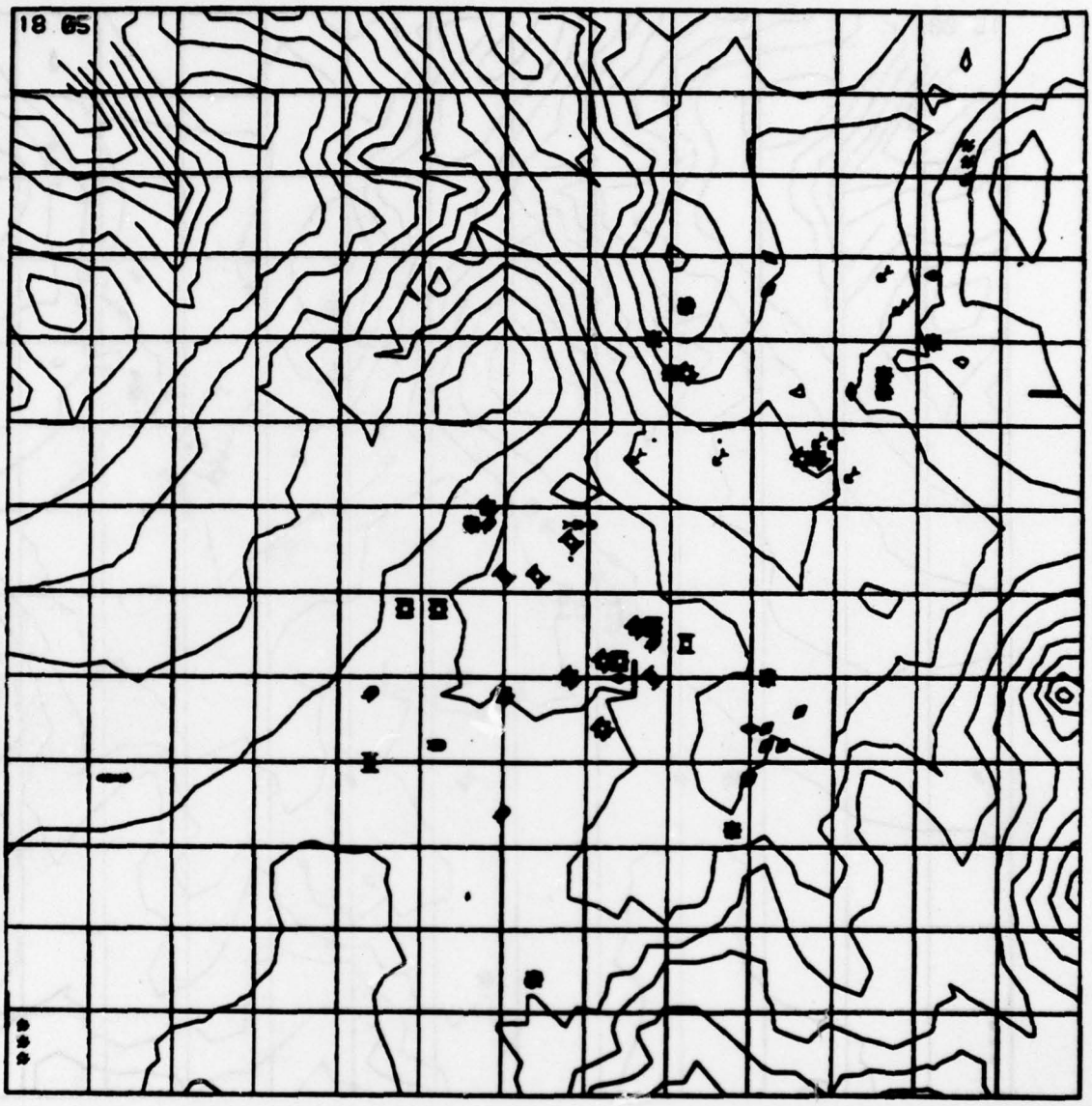

Figure B-29. T-tank disposition at termination of deliberate attack.

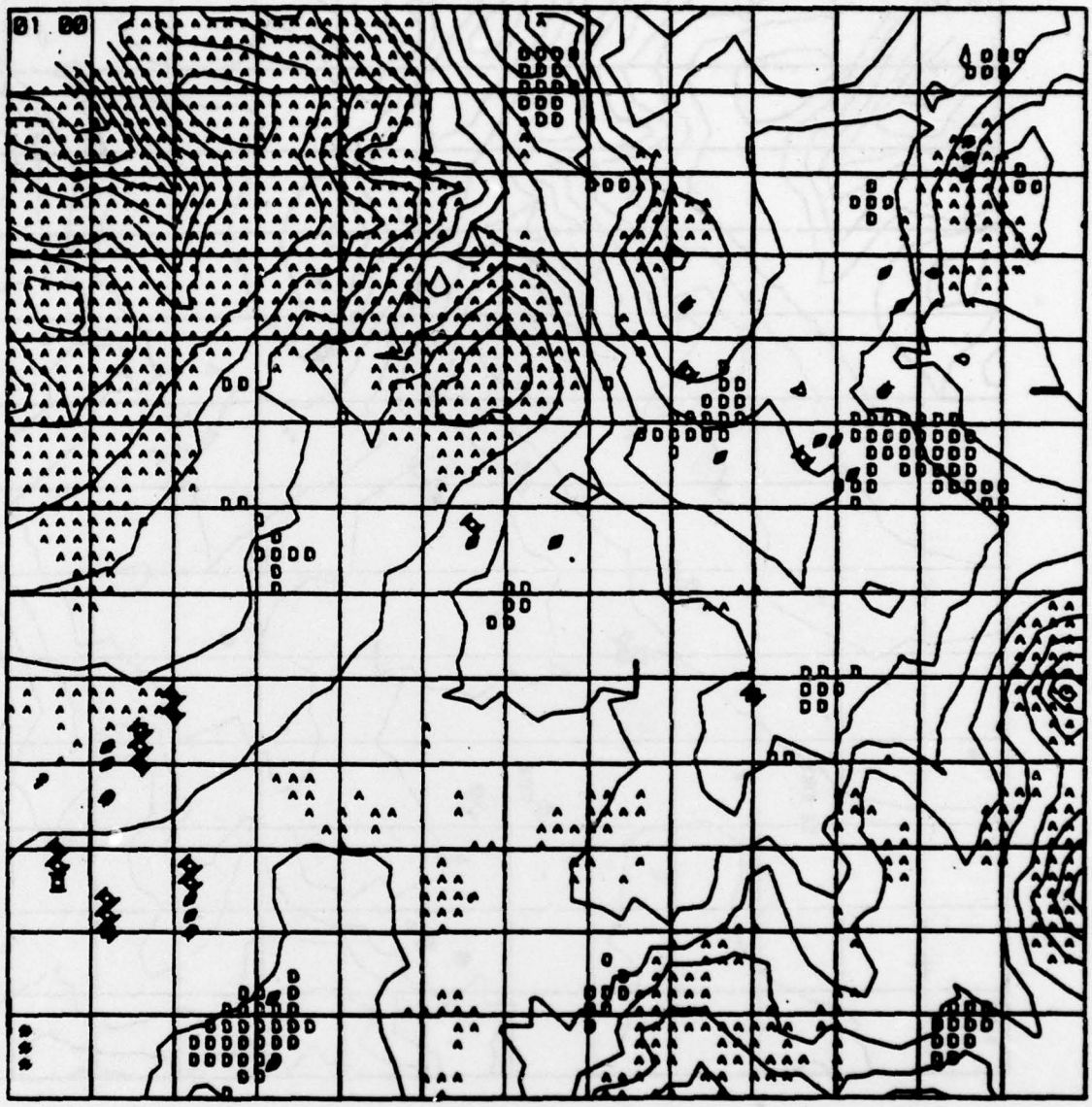

Figure B-30. H-tank initial positions for deliberate attack.

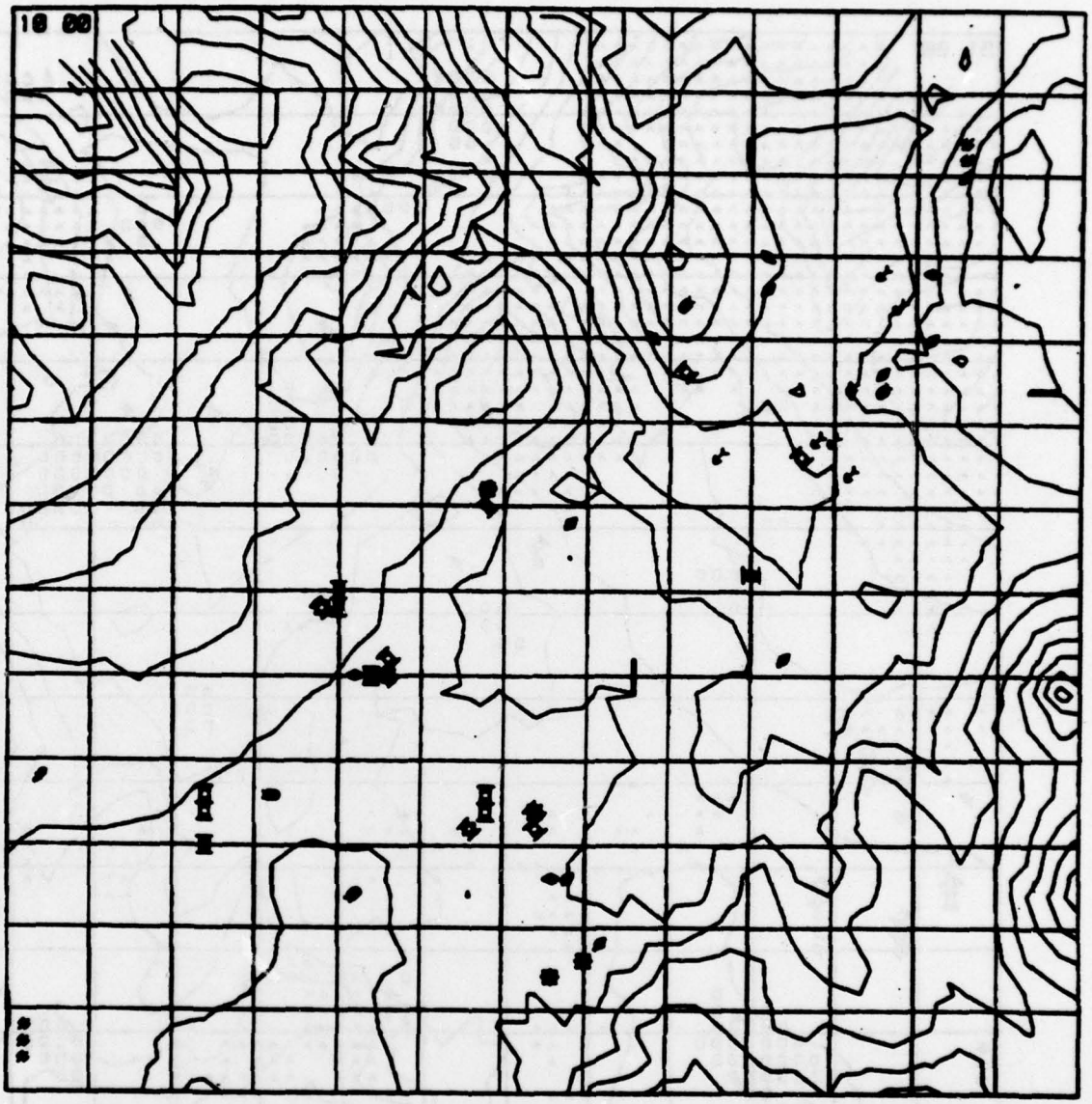

Figure B-31. H-tank situation after 10 minutes of contact in deliberate attack.

(d) The Blue units pressed their attack, engaging enemy weapons systems whenever identified. Blue artillery fires were adjusted by FIST elements on Red positions, which Red artillery engaged the advancing Blue units. By minute 17, the Red force was judged to be ineffective and the remaining Blue attackers were moving into and through the Red positions (figure B-32).

(3) Area 2 Offense Scenario, T-Mech Battalion TF.

(a) The TF was organized for combat similarly to the T-Tank TF. Two pure mech infantry companies, reinforced by two TOW sections, were assigned responsibility for the left and right flanks of the TF zone. The tank company (pure) was given responsibility for the center. Again, the battalion Scout section was ordered to screen the right flank and maintain contact with the adjacent battalion. Two TOW sections were earmarked as the TF reserve. The TF advanced along three avenues of attack. (See figure B-33 for dispositions.)

(b) The 15-minute Blue artillery preparation opened the battle, covering the deployment of the TF into combat formation. At minute 15, the Blue attackers were detected and engaged by Red outposts employing tank fires and Sagger missiles. Losses to Red fires were on a ratio of approximately 2 to 1. Initially, the majority of these losses occurred along the more exposed avenue on the left flank of the TF zone (figure B-34).

(c) By minute 17 (figure B-35), the Red defenders had been destroyed by the Blue attackers. At that time, Blue elements were advancing into the Red defensive positions.

(4) Area 2 Offense Scenario, H-Mech Battalion TF.

(a) Figure B-36 shows the dispositions of the H-Mech Battalion TF as they move into their attack positions. The two mech infantry company teams have each received attachments of a tank platoon and a TOW section. As in the H-Tank battle, the Scout platoon was screening the right flank and a mech platoon had been designated as the battalion reserve. A 15-minute artillery preparation had been arranged for the TF.

(b) By minute 7 the lead elements of the Blue TF had been identified by the Red outposts. Direct fire systems from both Red and Blue had engaged the enemy forces. The Red outposts withdrew, having fired two rounds each at the Blue attackers. During the withdrawal of the Red outposts, half of the combat vehicles were lost to Blue fires.

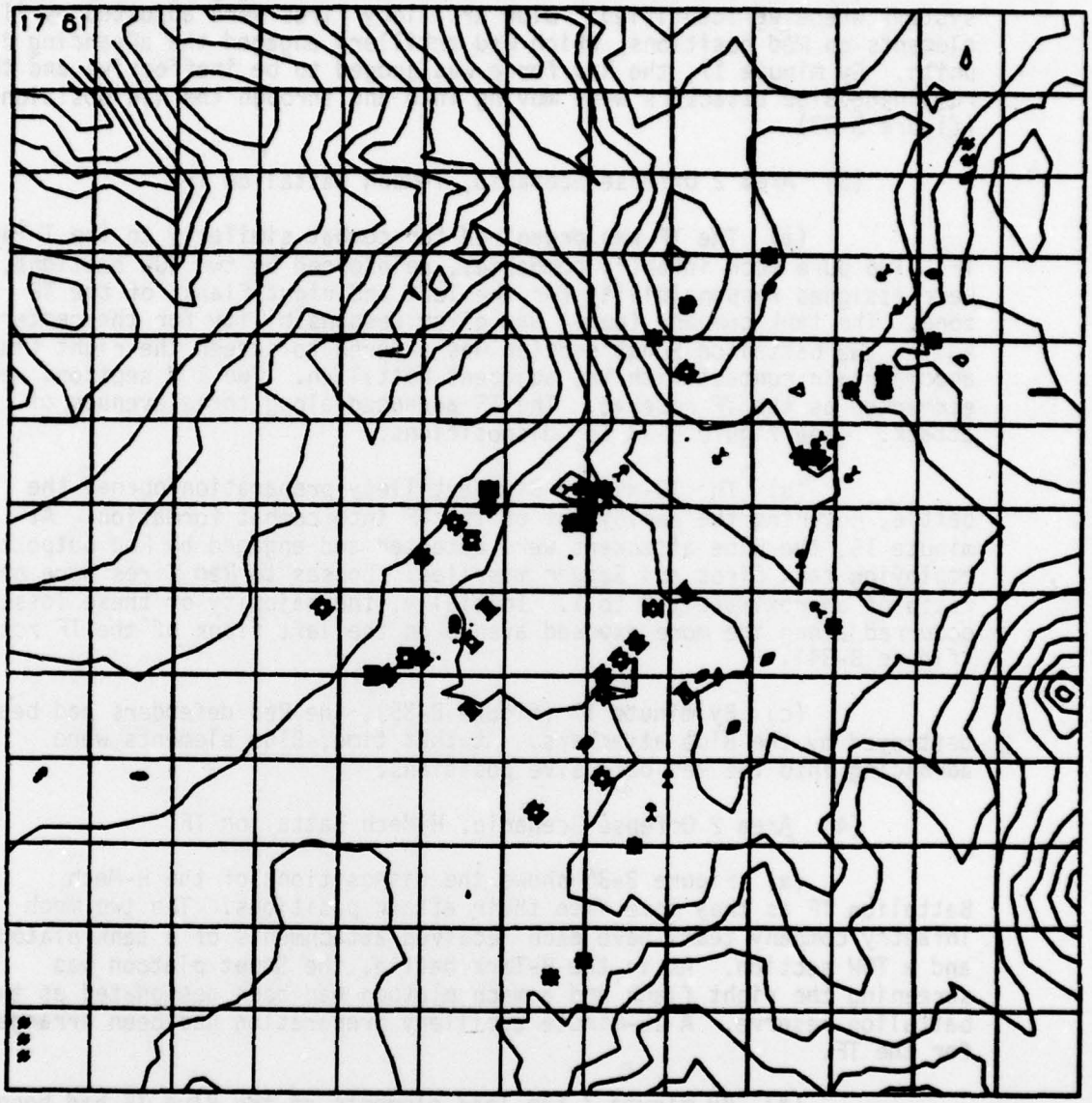

Figure B-32. H-tank disposition at termination of deliberate attack.

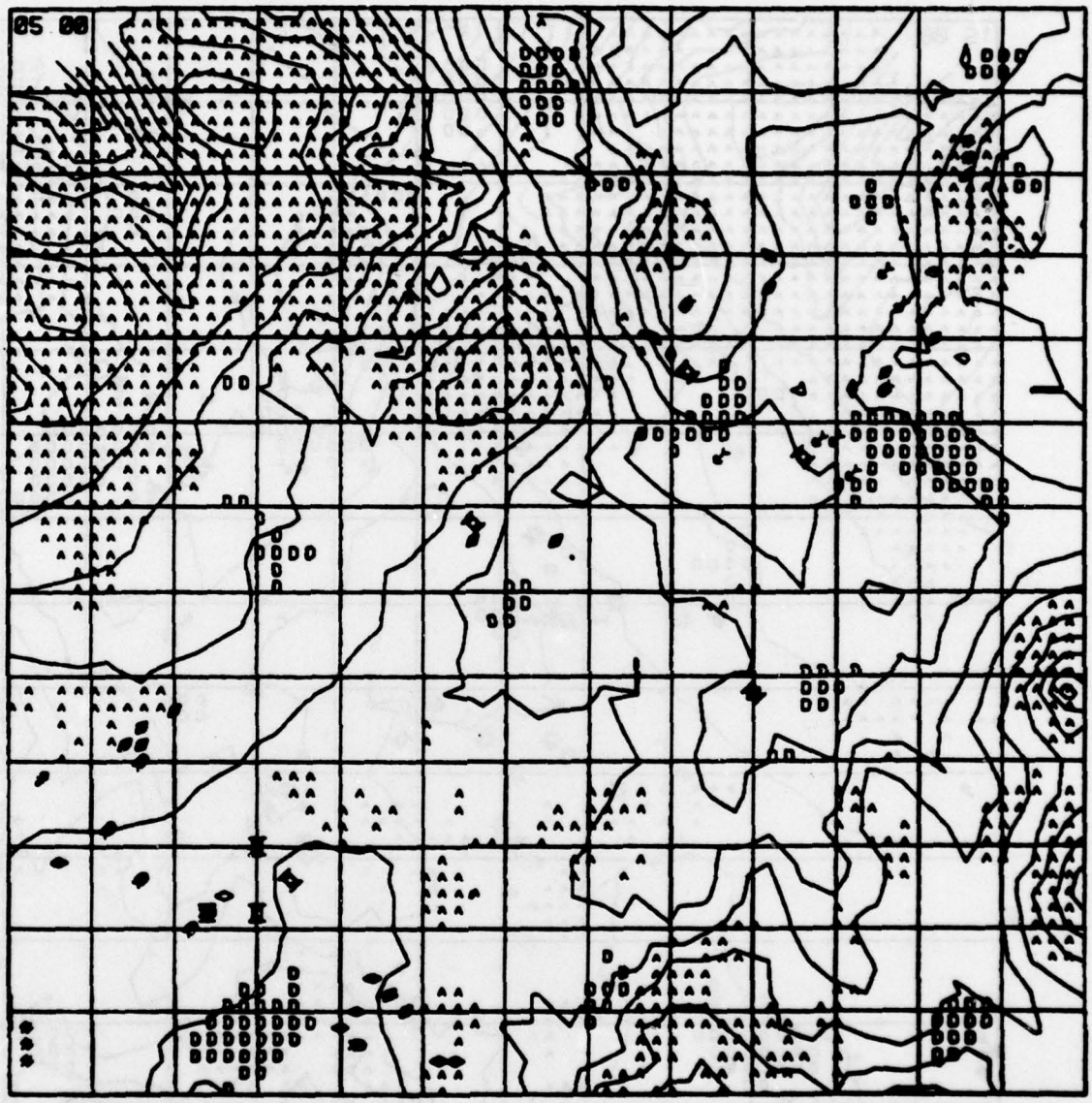

Figure B-33. T-mech disposition after conducting 5 minutes of deliberate attack.

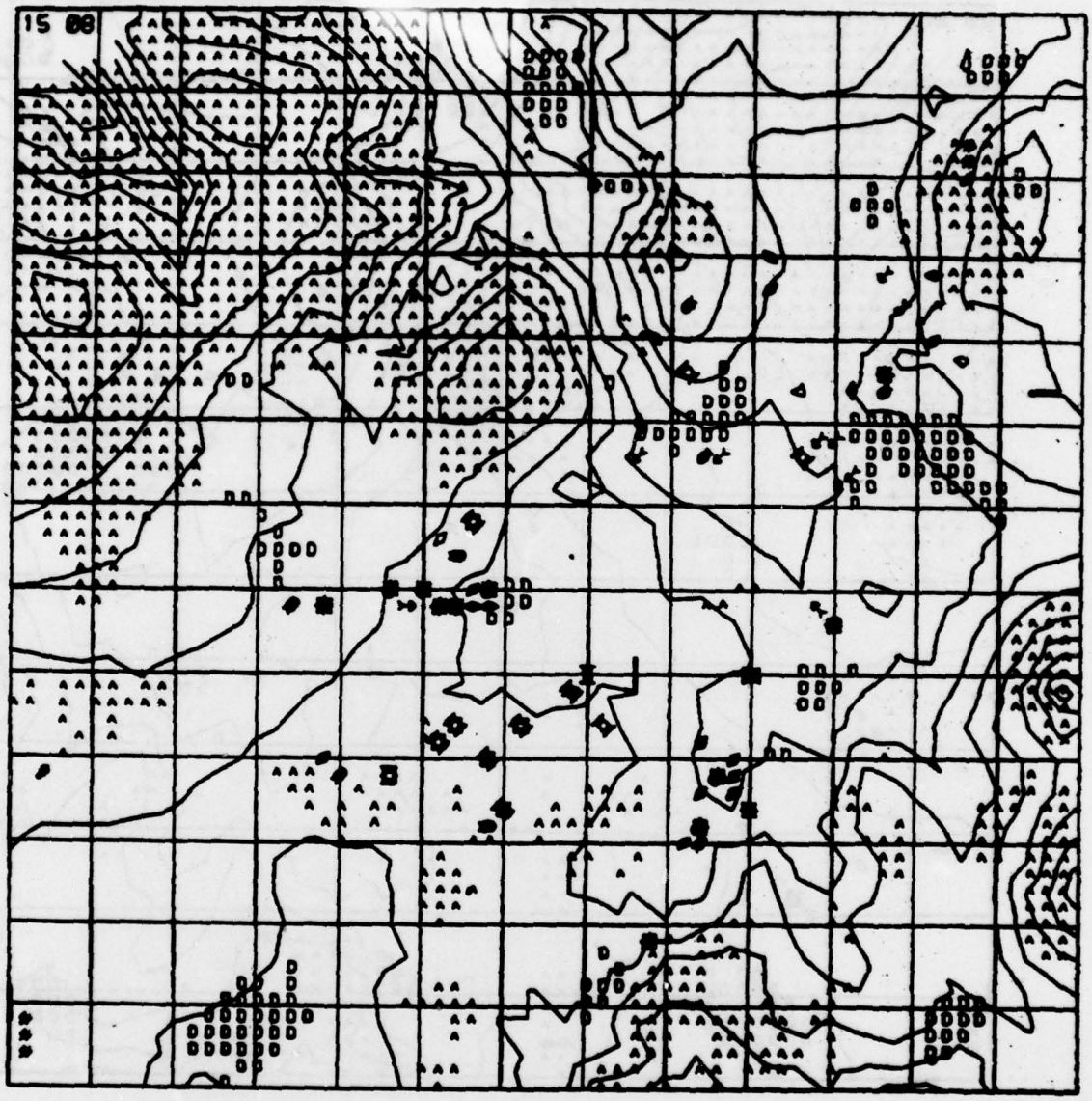

Figure B-34. T-mech situation after 15 minutes of deliberate attack.

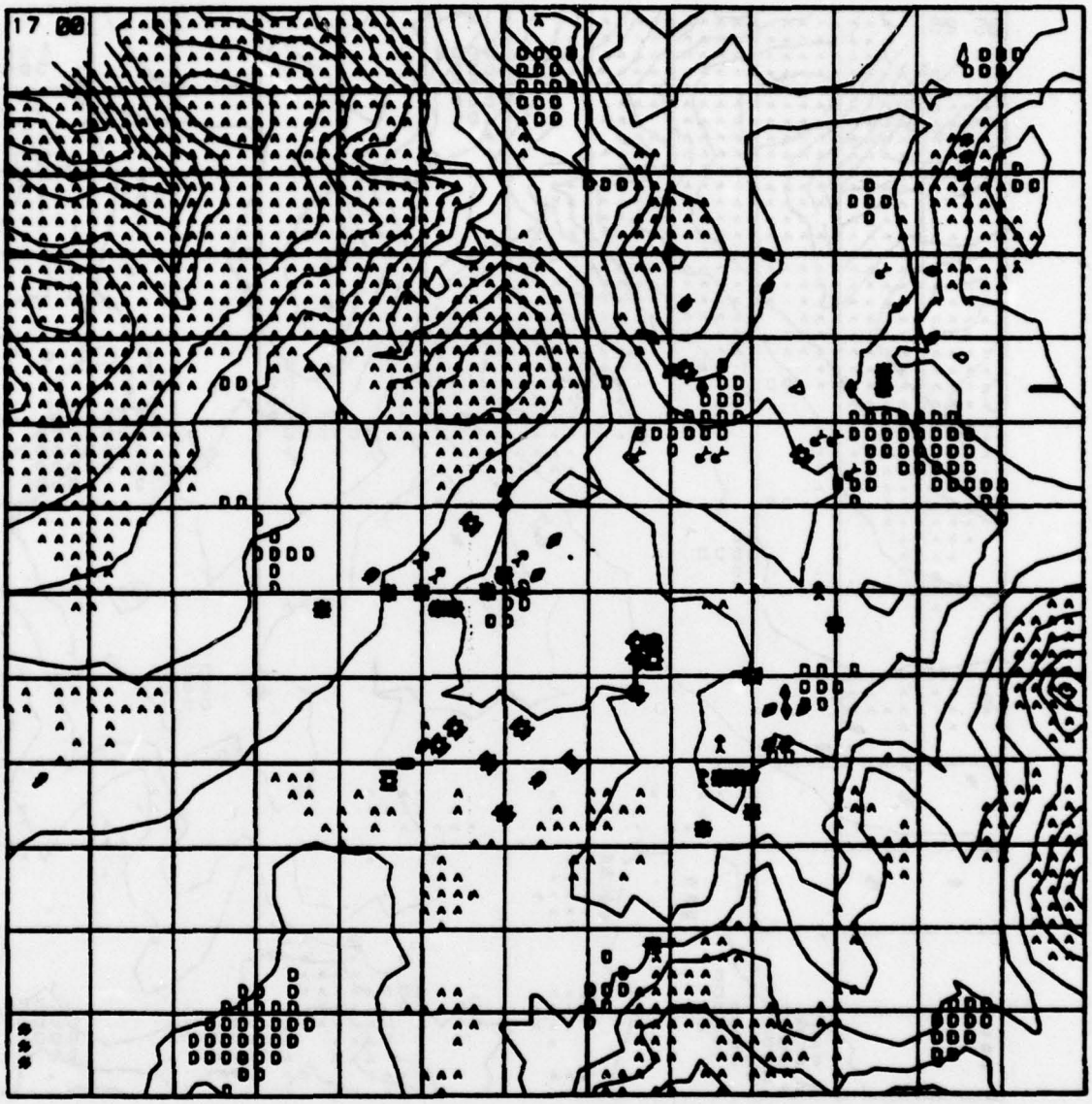

Figure B-35. T-mech disposition at termination of deliberate attack.

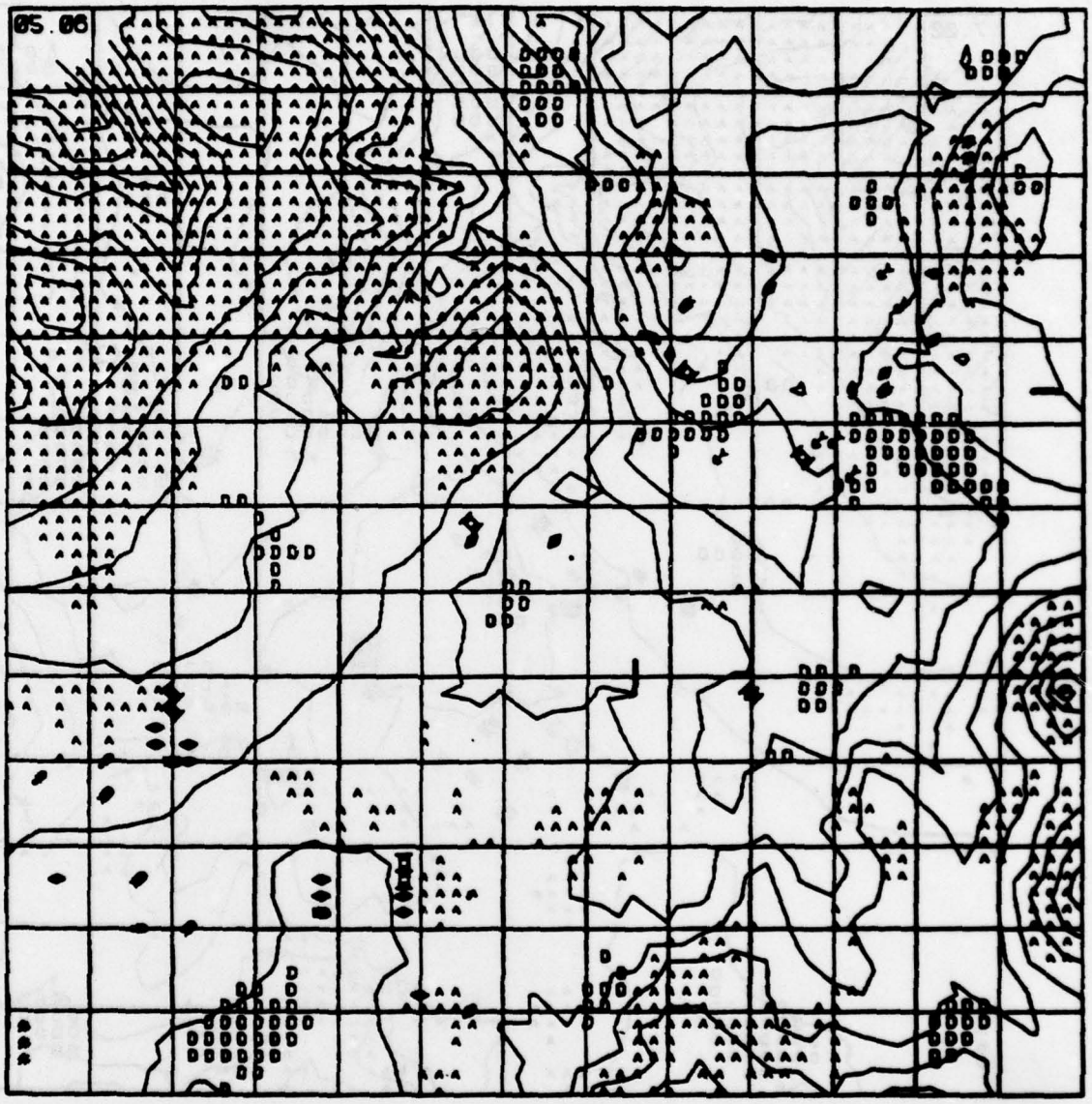

Figure B-36. H-mech disposition after 5 minutes of deliberate attack.

(c) By minute 15, 60 percent to 75 percent of the Red combat vehicles were destroyed, the majority by Blue direct fire systems. At the same time, Blue has lost about one-third of their force. The Blue losses were evenly distributed among the attacking company teams (figure B-37).

(d) As of minute 16.5 (figure B-38), only two Red combat vehicles remained, and the left flank Blue company was entering the Red battle position. The Blue forces had suffered approximately 50 percent losses but was still considered to be combat effective and capable of continuing the attack.

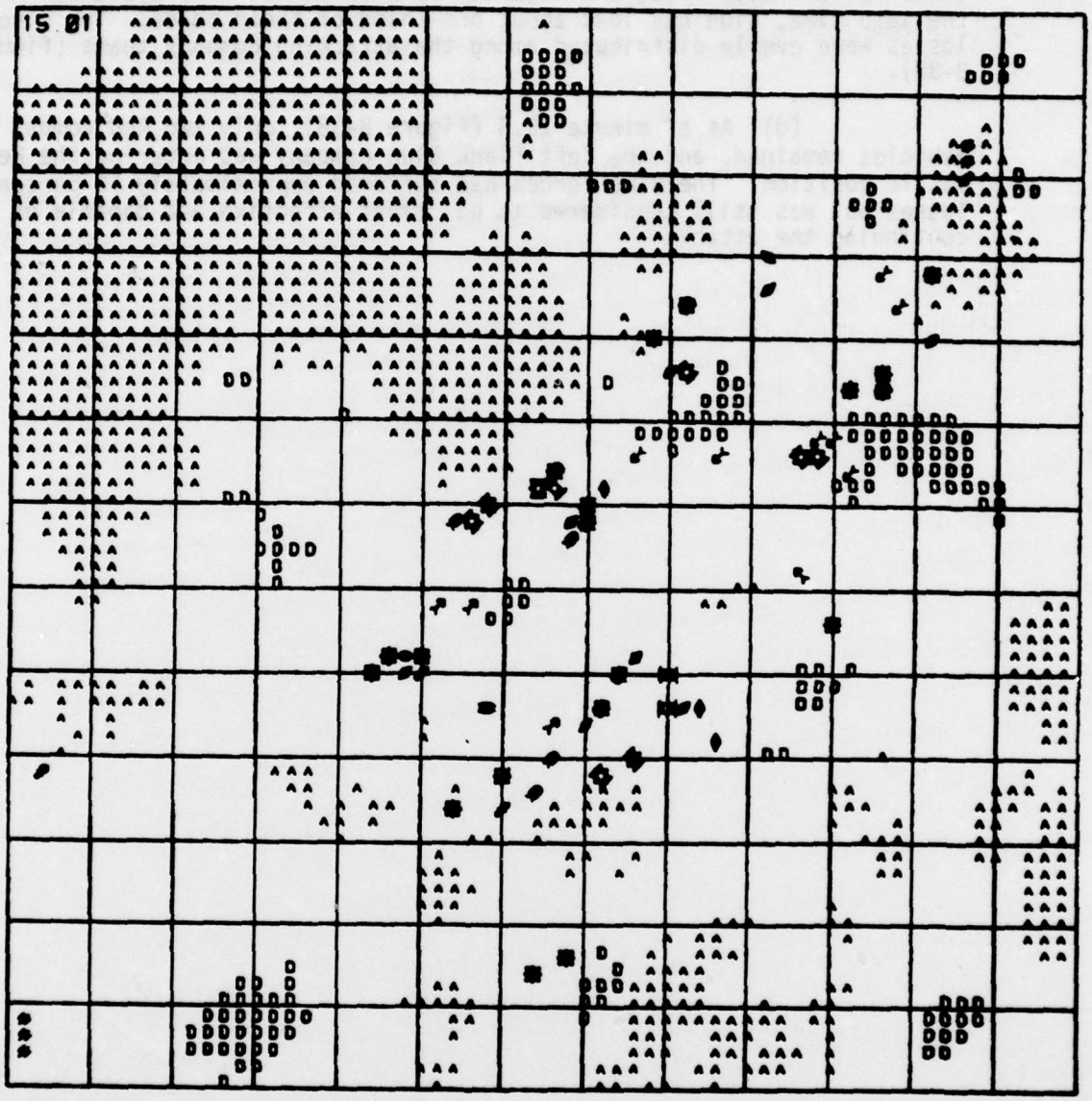

Figure B-37. H-mech situation after 15 minutes into the deliberate attack.

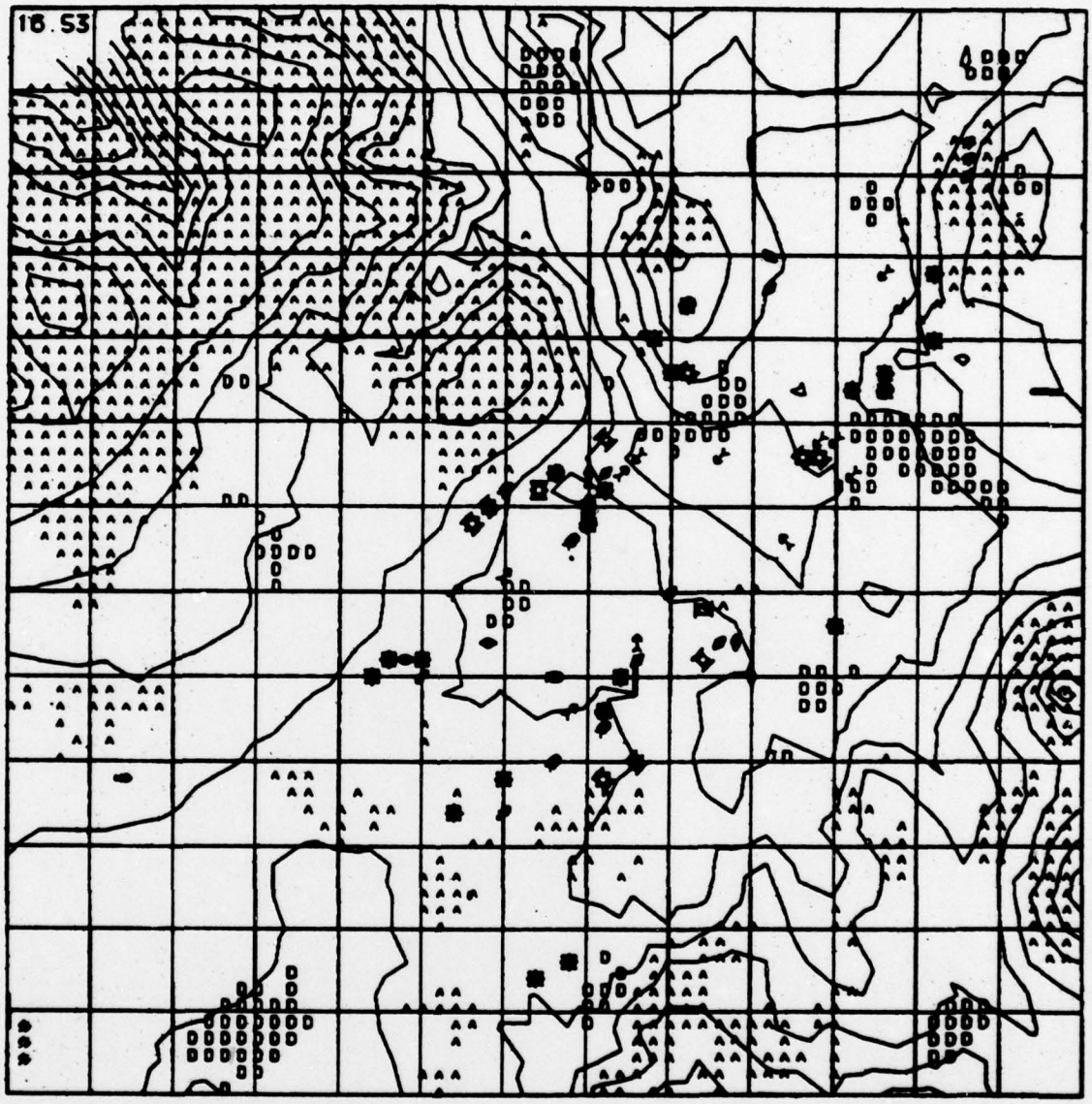

Figure B-38. H-mech disposition at termination of deliberate attack.

APPENDIX C

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H-Series vs T-Series Comparisons	Mech organizations
Offensive Scenarios	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This study examined the combat effectiveness of four alternative battalion task forces in various combat scenarios. CARMONETTE was used to model the combat. The report contains a description of the four alternative organizations, a discussion of the analysis methodology used, the results of the CARMONETTE gaming, the statistical and inferential analyses of the results, and the findings of the analyses. Also included in the report is a detailed description of the three combat scenarios used in the study.

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